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GROTON CT MARINE FIRE AND SAFETY RESEARCH STAFF
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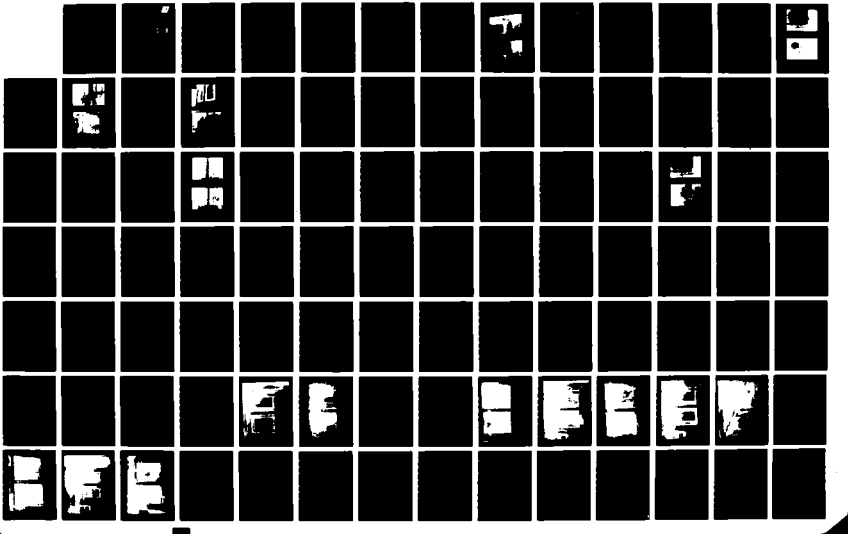

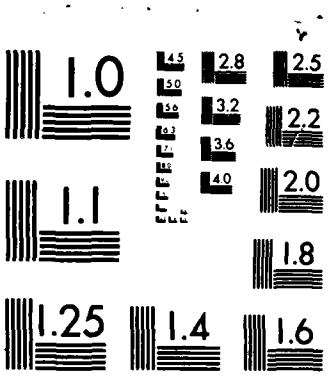

Report No. CG-M-1-87

U.S. Department of Transportation

United States Coast Guard

EVALUATING FIRE DOORS WITH HOSE PORTS

BY
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U.S. COAST GUARD
MARINE TECHNICAL & HAZARDOUS MATERIALS DIVISION

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16. Abstract

A test program was conducted to evaluate whether hose ports in fire doors compromise the fire integrity of the doors. Four fire doors were built according to Coast Guard construction requirements and were insulated for a Class A-15 fire rating. The doors were tested in accordance with the ASTM E152 "Standard Methods for Fire Tests of Door Assemblies". The testing was carried out by Underwriters Laboratories in Chicago, Illinois under the direction of the United States Coast Guard.

Two fire tests were conducted. Each test contained two Class A-15 fire doors installed in Class A-60 bulkheads. Each fire door assembly consisted of a frame, sill, hinges, a latch, a door and a hose port. Three of the doors contained a hose port. The fourth door did not have a hose port and was used as a baseline for comparison. Two single hinge hose ports and one double hinge hose port were used in the testing. Each fire door assembly was installed in a steel bulkhead to insure a test setup similar to normal shipboard installation. After the one hour fire test, the test panel was immediately removed from the furnace and the door assemblies subjected to the hose stream test specified in ASTM E152. Results show: (1) hose ports do not noticeably degrade the structural fire protection of a fire door, (2) fire doors built to Coast Guard construction requirements failed the performance requirements for the ASTM E152 fire test and (3) in the ASTM E152 test, a door positioned to swing into the furnace is a more severe test setup than a door positioned to swing away from the furnace.

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METRIC CONVERSION FACTORS

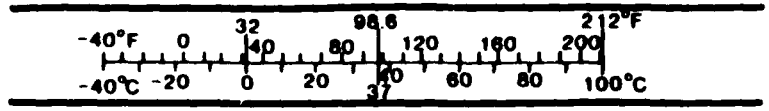
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	* 2 5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0 9	meters	m
mi	miles	1 6	kilometers	km
		AREA		
in^2	square inches	6 5	square centimeters	cm^2
ft^2	square feet	0 09	square meters	m^2
yd^2	square yards	0 8	square meters	m^2
mi^2	square miles	2 6	square kilometers	km^2
	acres	0 4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0 45	kilograms	kg
	short tons (2000 lb)	0 9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0 24	liters	l
pt	pints	0 47	liters	l
qt	quarts	0 95	liters	l
gal	gallons	3 8	liters	l
ft^3	cubic feet	0 03	cubic meters	m^3
yd^3	cubic yards	0 76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2 54 (exactly) For other exact conversions and more detailed tables, see NBS Misc Publ 286 Units of Weights and Measures Price $2 25
SD Catalog No C13 10 286

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 OBJECTIVES

The primary objective of this test series was to evaluate fire doors containing hose ports to determine if the ports degrade the structural fire integrity of the doors. A second objective was to evaluate the performance of fire doors built to Coast Guard construction requirements when submitted to a standard fire door test.

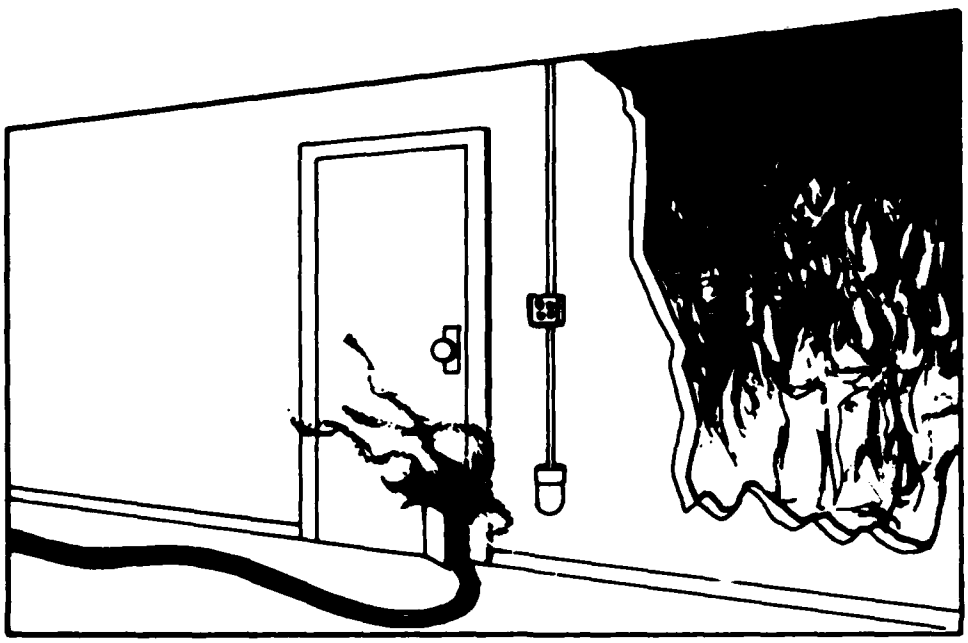
2.0 BACKGROUND

Fire hoses left in doorways can easily contribute to the fire damage of a ship by permitting the passage of flame and smoke through the open doorway. An example of this is the fire damage resulting to the passenger ship M/V SCANDINAVIAN SEA when a fire occurred on board and doors were blocked open by fire hoses. As a result of this damage, the National Transportation Safety Board(NTSB) recommended that passenger ships be required to have hose ports in all fire doors. U.S. passenger vessel regulations currently permit hose ports in doors except water-tight doors and doors in main vertical zone bulkheads. Before requiring hose ports in fire doors, it must be determined if they reduce fire safety by degrading the integrity of a door to prevent the passage of flame and smoke.

A hose port is a small opening in a door through which a fire hose can be pulled and/or left in place while fire fighting efforts are taking place. Normally, the opening is closed by a metal cover. The hose port even when open or containing a hose is a greater deterrent to the passage of smoke and flame than a door which is blocked open by a fire hose (Figure 1). This is due to the smaller open area available for the passage of flames, heat, and smoke. In addition, the hose port is installed in the bottom of a door where heat and smoke are less severe in most fires. A door which is blocked open by a fire hose creates a large opening at the top of the door where heat and smoke would accumulate first thus creating an easy passage for these elements.

Coast Guard regulations require that when hose ports are installed they shall be cut in the lowest corner of the door on the side opposite the hinge so that if the hose is passed through the doorway when the door is open, the door may be closed over the hose (Reference 1). The cutout for the hose port should be approximately six inches (15.24 cm) square. A hinged or pivoted steel or equivalent metal cover shall be fitted in the cut and equipped with a bullet catch or similar method of fastening which will permit easy and automatic operation of the hinged cover. A hose port may be constructed with a single acting hinge which permits it to move in only one direction or it may have a double acting hinge which permits it to move in two directions (Figure 2).

DOOR BLOCKED OPEN BY HOSELINE



HOSE PORT

FIGURE 1. FIRE CONDITIONS

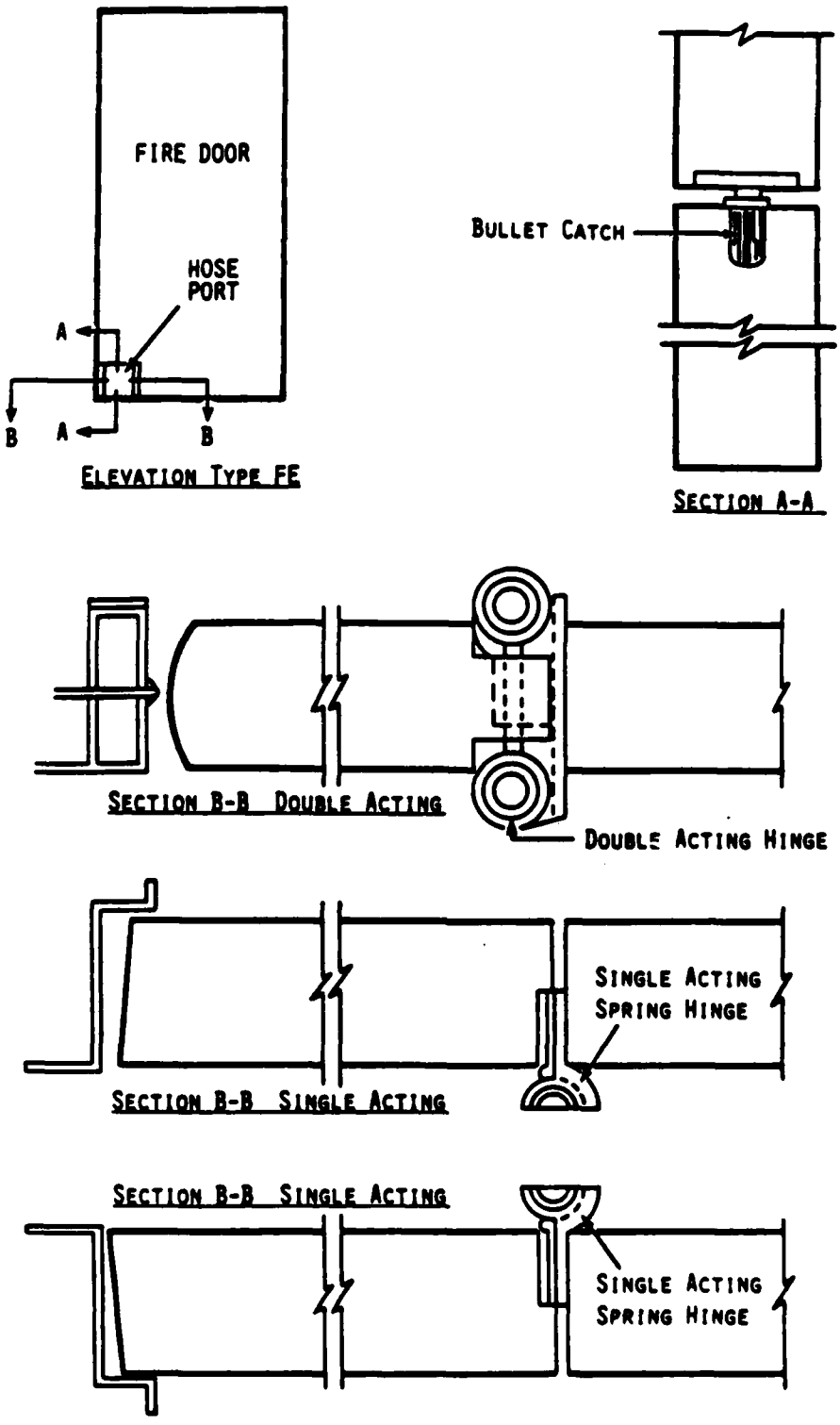


FIGURE 2. FIRE DOOR/HOSE PORT DETAILS

3.0 APPROACH

The approach was to procure several fire doors with hose ports and evaluate them in a reproducible fire test to determine if they exhibit the same degree of fire protection as a fire door without a hose port. Coast Guard regulations require that fire doors on merchant vessels provide the same fire integrity as the bulkhead division in which they are installed (Reference 2). Therefore, a fire door with a hose port should exhibit the same degree of fire protection as a fire door without a hose port.

ASTM E152 "Standard Method of Fire Tests of Door Assemblies" was selected as the test procedure for evaluating the fire doors with hose ports. This test follows the same standard time temperature curve used in the Coast Guard approval test(ASTM E119 "Fire Tests of Building Construction and Materials") used for bulkheads (reference 3). The ASTM E152 test however is intended for evaluating the structural fire resistance of fire door assemblies. Additional instrumentation and measurements were included to evaluate the passage of smoke and flame. For these tests, the fire doors were installed in a steel bulkhead to insure a realistic situation as found on board ships.

Unlike bulkheads and decks, Coast Guard regulations do not require fire doors to meet any fire test requirements (Reference 4). It is felt that due to the limited amount of combustibles stowed adjacent to the door, an equivalent amount of integrity could be provided by specifying construction requirements for doors. For example, fire doors installed in Class A-0 bulkheads must be of steel or equivalent metal construction. Generally, a double thickness of 16 USSG or a single thickness of 11 USSG is acceptable. Test requirements are also not demanded for hardware such as hinges, frames, or latches but manufactures generally use steel components to match the integrity of the door.

3.1 Standard Fire Door Tests

A single fire test assessing the ability of a fire door to provide the same fire integrity as a bulkhead is lacking. The major acceptance requirements for various fire test standards are different in their demands. For example the Coast Guard fire test for bulkhead panels(CFR 164.008) does not address any fire standards for doors or door hardware although it does include limitations on openings formed through the bulkhead and restrictions for smoke and flame passage. The ASTM E152 test can be used to assess the ability of a fire door(and hose port) to provide certain structural requirements but it has no

acceptance standards for smoke and flame penetration. The Underwriters Laboratories test (UL 10B) has structural stability acceptance requirements but it will also permit flaming on the unexposed side after the first 30 minutes of the test (Reference 5). The International Maritime Organization (IMO) does not allow flame penetration or flaming on the unexposed side. It also has acceptance standards for temperature rise on the unexposed side of the doors(Reference 6). The IMO test does not have movement regulations whereas they are specified in ASTM E152 and UL 10B.

3.2 Material Specifications for Fire Doors

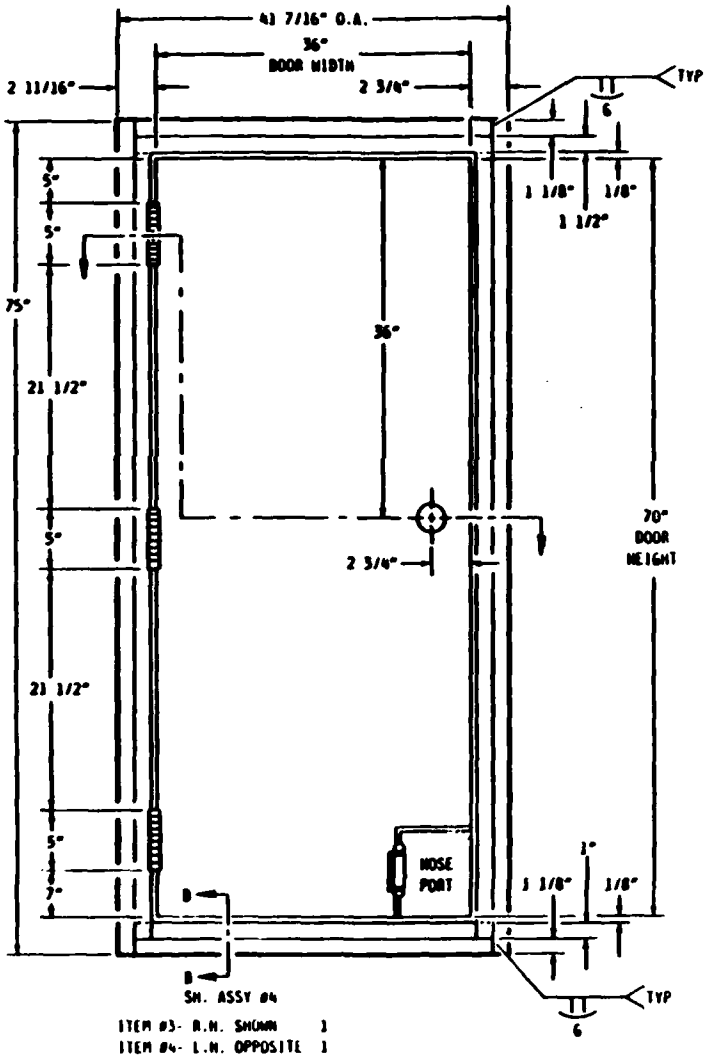
The standard material specifications for door assemblies as required by the above groups also vary. The Coast Guard requires a door to be of hollow steel or equivalent metal construction. If installed in a Class A-60,A-30, or A-15 bulkhead then the door must be filled with approved structural insulation capable of meeting the requirements for a Class A-15 bulkhead. It must also have a minimum latch size of 3/4 inch(1.9 cm) and also have a 1/2 inch (1.3 cm) door stop at the sides and top. IMO requires the door and frame to be constructed of steel or other equivalent material and insulated to achieve the desired standard of insulation. Hinges, latches, bolts and handles must be constructed of materials having melting points of not less than 950 degrees C (1744 degrees F). ASTM F821 (Reference 7) states a Class A-0 door should be 1 3/4 inches (4.4 cm) thick. It should also be of hollow steel construction with a minimum of 16 USSG plates and have a 3/4 inch(1.9 cm) latch. A Class A-0 door must have three equally spaced hinges. U.L. does not have a materials specification for doors.

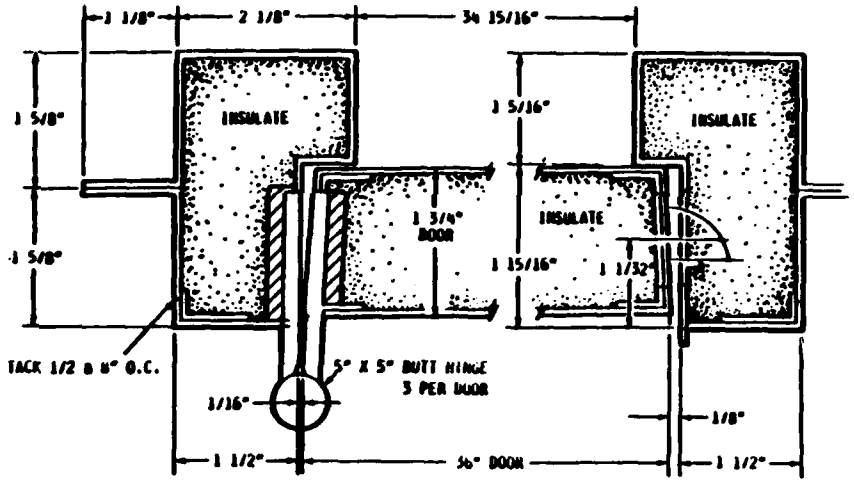
4.0 FIRE DOOR SPECIFICATIONS

All fire door assemblies were provided by one manufacturer to eliminate the variable of different designs or different materials used in construction. Each door assembly consisted of a hollow-metal door, pressed steel frame, three mortise hinges and a mortise latch. The door and frame were insulated for a Class A-15 rating. Three of the doors were fitted with a hose port at the bottom latch edge corner of the door. One door did not contain a hose port. Each door assembly was installed in a steel bulkhead.

4.1 Fire Door Assemblies

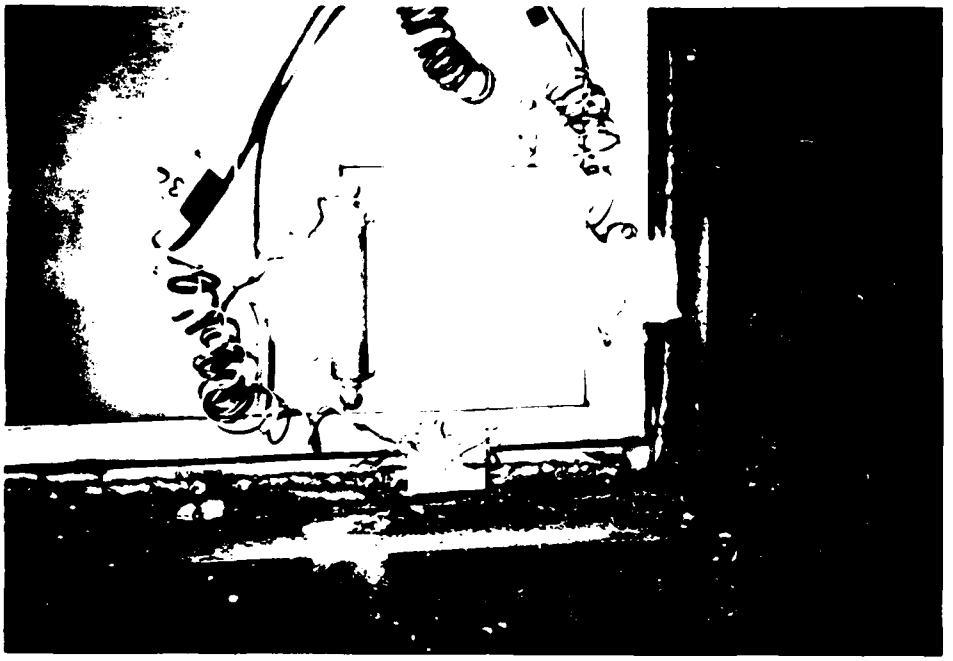
The door assemblies and hose ports were constructed to meet Coast Guard requirements in 46 CFR Subpart H 72.05.25. The dimensions of the door assemblies are shown in figure 3. The doors were





SECT A-A

FIGURE 3. DOOR ASSEMBLY DIMENSIONS



SINGLE HINGE

DOUBLE HINGE

FIGURE 4. HOSE PORTS

constructed of 16 USSG steel using a hollow hat channel design. The frames were constructed of 14 USSG steel. Each door was connected to its door frame by three steel hinges (4 1/2 by 4 1/2 inches)(11.4 by 11.4 cm) and contained a 3/4-inch (1.9 cm) steel latch. The door could be opened from either side. Each door was 1 3/4 inches (4.4 cm) thick, 70 inches (177.8 cm) high, and 36 inches (91.4 cm) wide. Each door frame had at least a 1/2-inch (1.3 cm) door stop at the top and on each side. The top and sides of the frame had a 1 1/8-inch (2.9 cm) steel edge. The frame contained a plain sill with a 1 1/8-inch (2.9 cm) under-edge and a 1/8-inch (0.3 cm) tolerance to the door. The doors were constructed to fit as snugly as possible to the frame at the jambs and sill. The doors did not contain a lock, stay-open hooks, magnetic catches, gaskets, glass, or louvers. All doors and hose ports were painted with primer and grey paint.

The steel hose ports were 6 inches (15.24 cm) square and equipped with a bullet catch. Two hose ports were fitted with a single acting hinge. One hose port was equipped with a double-acting hinge which allowed it to move both toward and away from the furnace. A single-acting hinge hose port and a double-acting hinge hose port are shown in figure 4.

4.2 Installation

U.L. installed the door assemblies in the steel bulkheads by welding the frame flange all the way around to the bulkhead. The bulkhead had stiffeners on the unexposed side to prevent warpage. The interface between the bulkhead assemblies and the test panel was sealed. Three inches (7.6 cm) of approved mineral wool structural insulation was applied to the fire side of the steel bulkhead. Steel pins were welded to the bulkhead and the insulation was impaled on the pins. This was followed by a wire mesh held to the pins by circular steel clips. The interface between the bulkhead assemblies and the test panel was sealed.

5.0 PROCEDURES

Underwriters Laboratories Inc. in Chicago, Illinois conducted the testing in a 14 x 14 x 2 1/2 foot (4.3 x 4.3 x 0.8 m) furnace (Figure 5). The fire tests were conducted in accordance with ASTM E152. Observations were made of the condition of the unexposed faces of the doors, the performance of the doors and hose ports, and the passage of flame and smoke through the assemblies.

TEST FRAME

FURNACE

FIGURE 5. U.L. TEST FURNACE

The UL furnace held two door assemblies per test (Figure 6). Two furnace tests were conducted. The four fire door assemblies were insulated for a Class A-15 rating. Three of the fire doors contained a hose port. One door was tested without a hose port as a baseline for comparison. Three of the fire doors (two with a hose port and one without a hose port) were positioned so that they would swing into the test furnace. The remaining fire door (with a hose port) was positioned to swing away from the test furnace. Figure 7 shows the test positioning of the doors. The fire door assemblies were positioned at a height in the furnace so that a a neutral test pressure would be maintained at the top of the hose ports.

5.1 Movement Measurements

Movement of each door assembly was determined by measuring the initial position of the door to the frame and taking a new measurement at the same area at different time intervals throughout the test. The difference of the two measurements indicated the total movement. The measurement locations are shown in figure 8.

5.2 Hose Stream Test

A hose stream test was conducted at the conclusion of the 60 minute fire test. The frame was withdrawn from the furnace and the assemblies were subjected to a 30 psi(207 kPa) hose stream for 18 seconds.

5.3 Flame Penetration Test

Flame penetration was indicated by testing for ignition of cotton wool pads placed over the gaps around the door and the hose port on the unexposed face of each door assembly. This was done in accordance with reference 2 at various times throughout the 60 minute test.

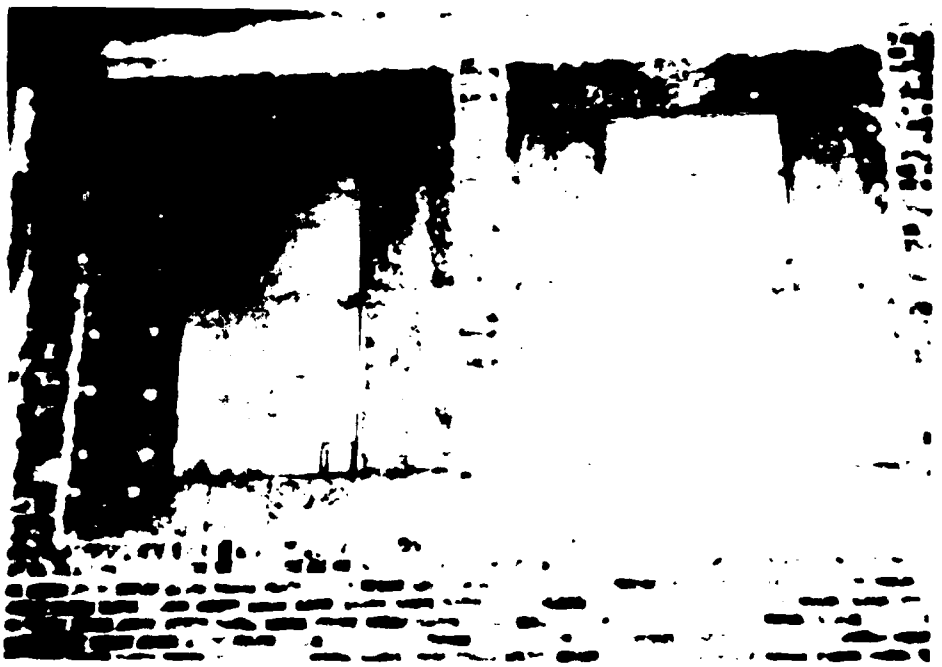
6.0 INSTRUMENTATION

The instrumentation required in ASTM E152 was used for all tests. Additional instrumentation was also used to assess the overall fire protection integrity of the door assemblies and to characterize the furnace conditions.

6.1 Furnace Temperature Profile

Temperatures within the furnace were controlled in accordance with the Standard Time Temperature Curve. Nine additional temperatures were measured in the furnace. The thermocouple

UNEXPOSED SIDE



EXPOSED SIDE

FIGURE 6. FIRE DOOR ASSEMBLIES BEFORE TEST

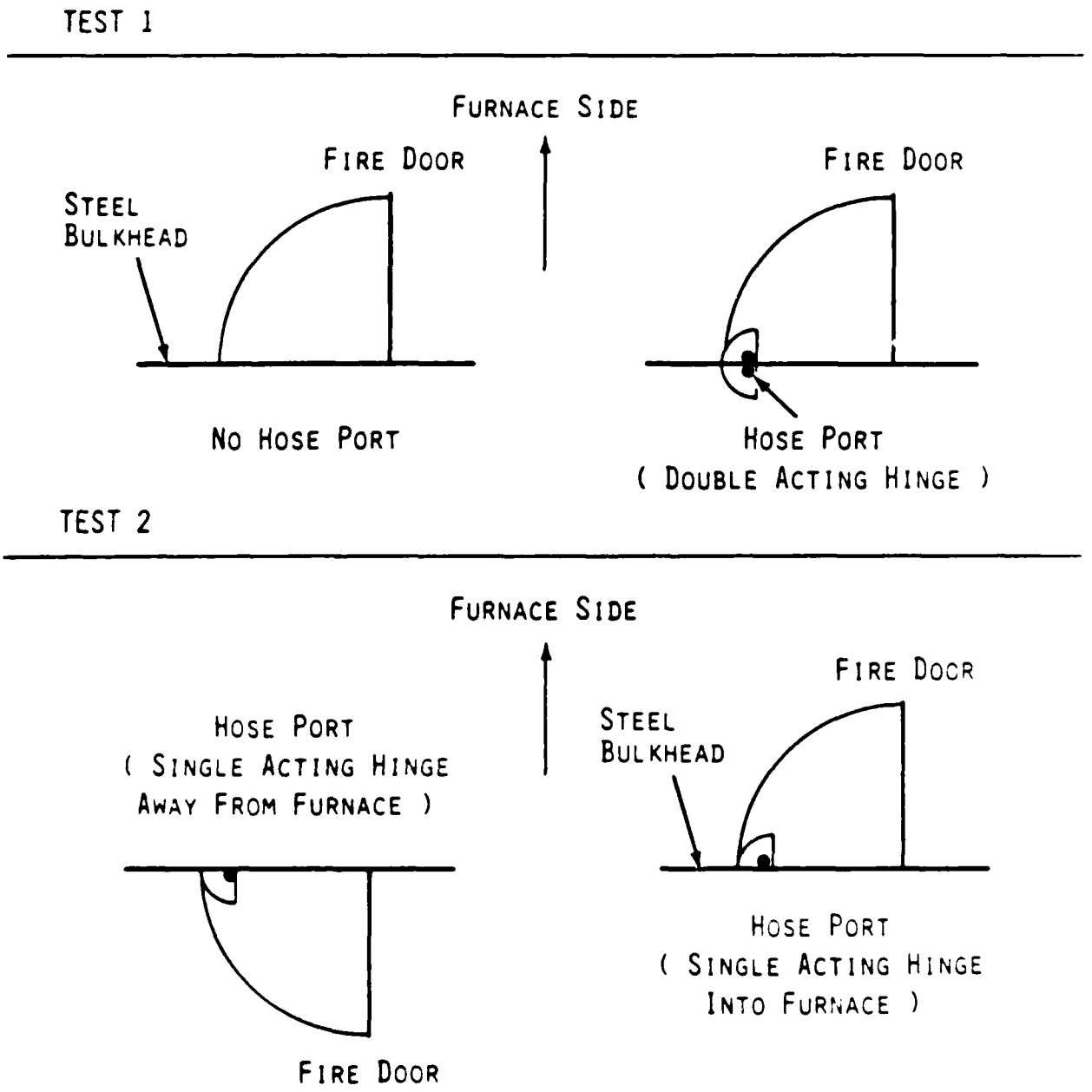
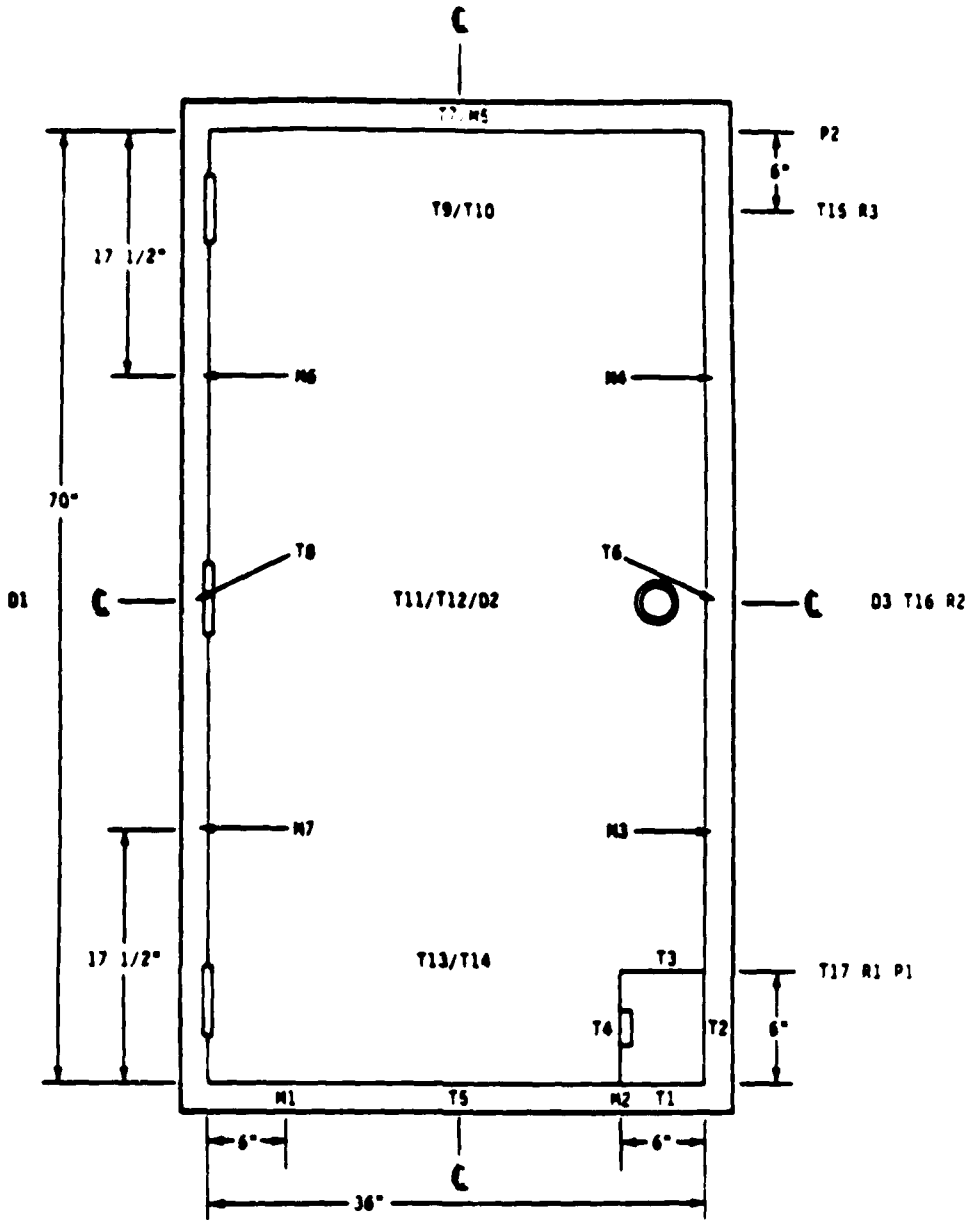


FIGURE 7. FIRE DOOR POSITIONING



INSTRUMENTATION/MEASUREMENTS

LEGEND T = Thermocouple R= Flux reading P= Pressure tap
M= Measurement location D= Deflection location;
T10, T12, T14 are on exposed face;
D1, D3, T15, T16, T17 are on bulkhead;
P1, P2, R1, R2, R3, are between bulkheads.

FIGURE 8. DOOR INSTRUMENTATION

locations are shown in figure 9. These thermocouples were located on a vertical plane at the front, middle and back of the furnace on its center line. Three thermocouples were located on each plane at the bottom, middle, and top level of the doors. Quick-response type shielded furnace thermocouples were used to record furnace temperatures.

6.2 Door Temperatures

Temperatures were measured on both the exposed and unexposed face of the doors. Thermocouples used in the testing were of the type specified in the U.S.C. G. Specification for Bulkhead Panels 46 CFR 164.008. Four temperatures were recorded between the door and door frame and four temperatures were recorded between the hose port and the door. The positions of the thermocouples used for these measurements are shown in figure 8.

6.3 Heat Flux

Heat flux measurements were made for each test inside the furnace at the locations shown in figure 10. Two calorimeters were installed between the steel bulkheads, one at a level of 7 1/2 inches (19.1 cm) above the bottom of the doors, and one at a level of 7 1/2 inches (19.1 cm) below the top of the doors. A radiometer was installed midway between the two calorimeters.

6.4 Pressure

The fire door assemblies were placed in the furnace such that the top edge of the hose port was located at a height where a neutral pressure was produced. Measurements of the static pressure were made with two pressure taps shown in figure 10. The taps were located between the steel bulkheads, one at the height of the top of the door and one at the height of top of the hose port.

6.5 Documentation

The thermocouples, heat flux and pressure data were recorded by computer data acquisition equipment. Each test was recorded with a video camera/recorder. A 35mm camera was used to take pictures of the test at five minute intervals.

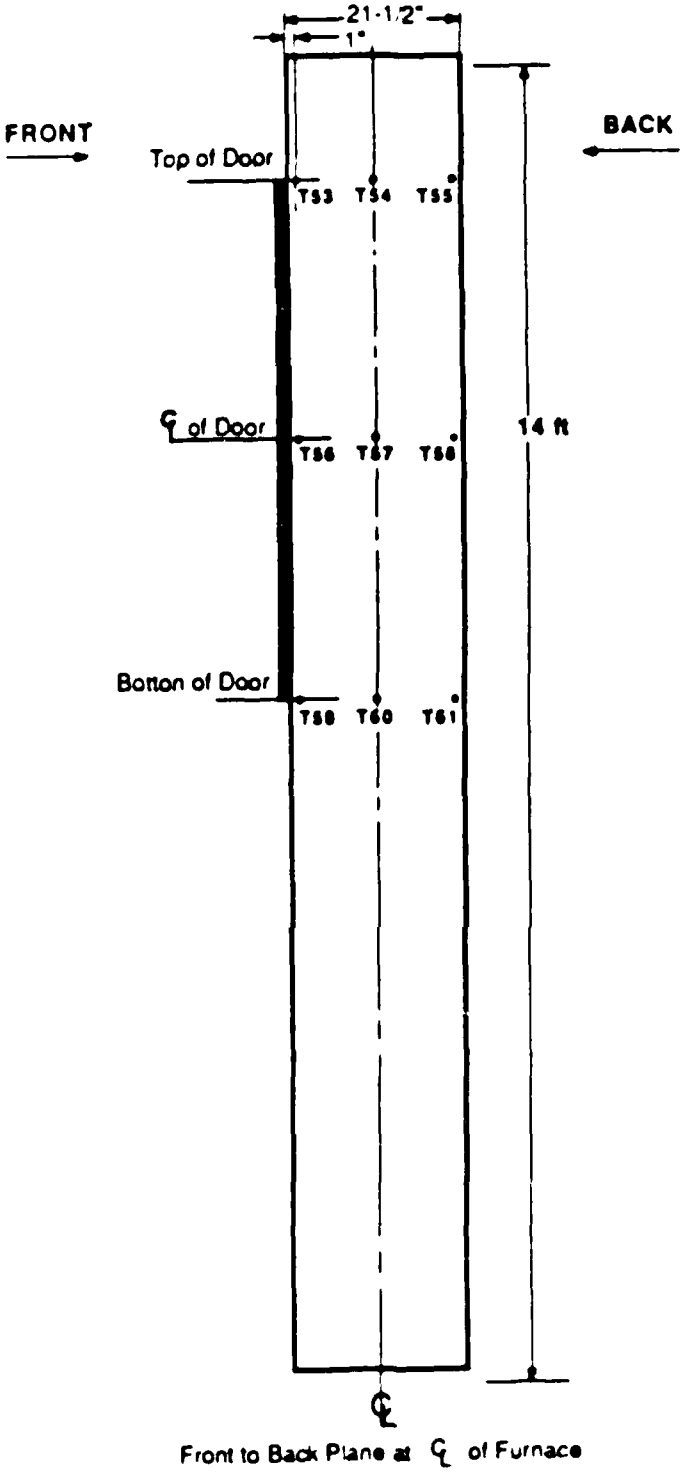
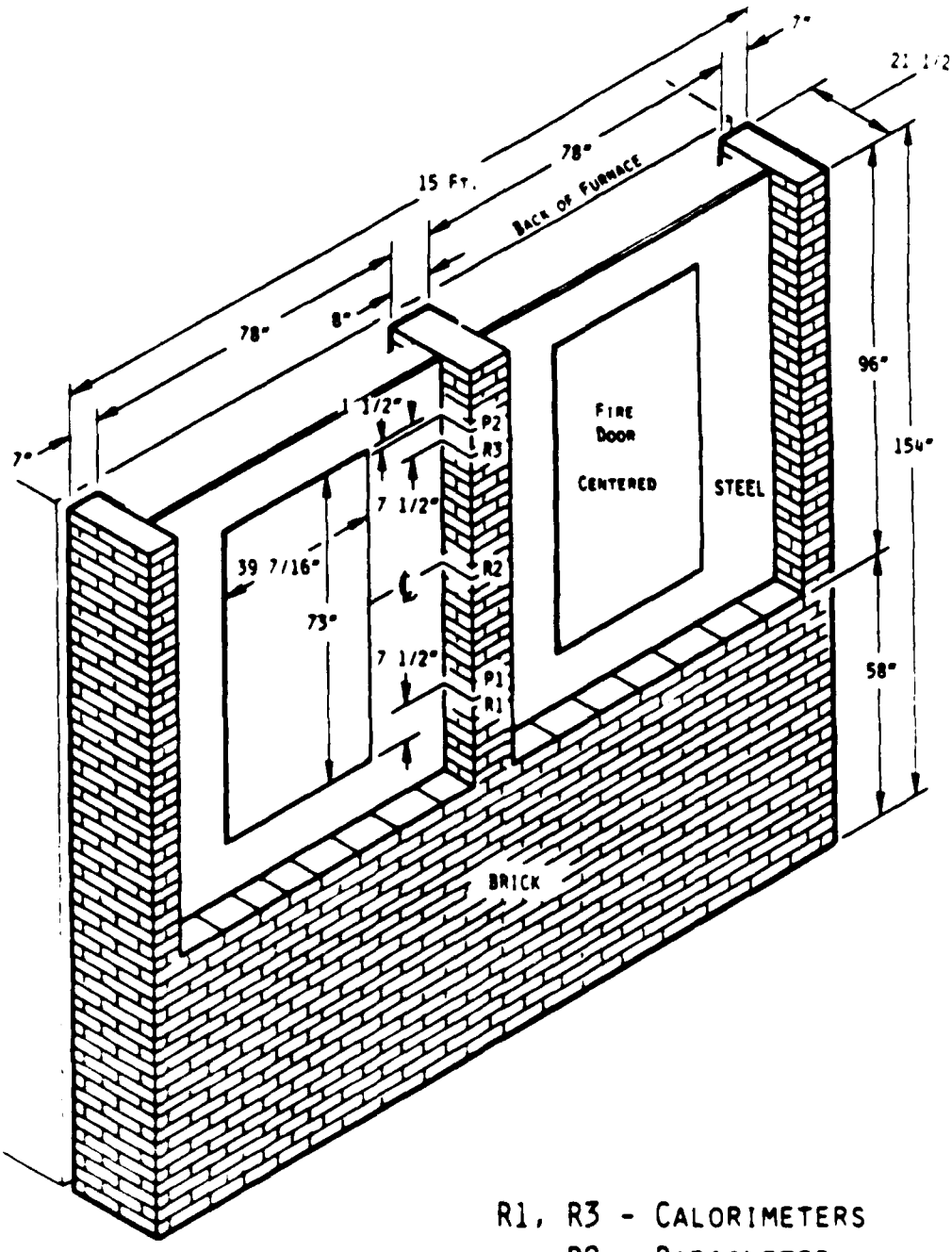


FIGURE 9. THERMOCOUPLES IN FURNACE



R1, R3 - Calorimeters
R2 - Radiometer
P1, P2 - Pressure Taps

FIGURE 10. HEAT FLUX AND PRESSURE INSTRUMENTATION

7.0 RESULTS AND DISCUSSION

7.1 Test Conditions

The pressure conditions measured inside the furnace for both tests are shown in figure 11. This figure shows that for test 1 and test 2 the pressures recorded at the top of the door and at the top of the hose port followed a parallel pattern with the upper level pressures being almost ten times greater than the lower level pressures. The pressures at the upper level in test 1 and test 2 varied from each other for the first 30 minutes but then leveled off to similar values. This is also true for the pressures at the lower level. The pressures recorded at the top of the hose post were close to neutral in each test.

Temperature histories were measured for nine locations inside the section of the furnace containing the door assemblies. These temperature histories as shown in figure 12 indicate that the fire door assemblies were exposed to similar temperatures at the top of the door, the middle of the door, and the top of the hose port. This same condition existed in test 1 and test 2.

Figure 13 shows that the heat flux measurements in the furnace at the top of the door and at the top of the hose port (bottom of door) were greater in test 2 than in test 1. This figure also shows that the heat flux measurements were similar at the different locations for test 2 while the heat flux measurements at the different locations for test 1 had a great degree of difference.

Temperatures were measured at three points on the exposed and the unexposed side of the doors. These points were opposite each other and were at the top, middle, and bottom of the doors. Figures 14 and 15 show similar temperature histories for all the points on the exposed side of the doors. These figures also show similar temperature histories for the points on the unexposed side of the doors but they are 600 to 800 degrees F (316 to 427 degrees C) lower than the temperatures on the exposed side of the doors.

Temperatures were measured on the unexposed side of one door assembly bulkhead and found to be within the acceptable limits for a Class A-60 fire rating (Figure 16). This figure shows the effectiveness of the insulation in maintaining similar temperatures at the top, middle and bottom of the bulkhead.

7.2 Door Assemblies

Visual observations made of both tests are listed in Appendix B (pages 7-10). It was noted that no openings developed in the

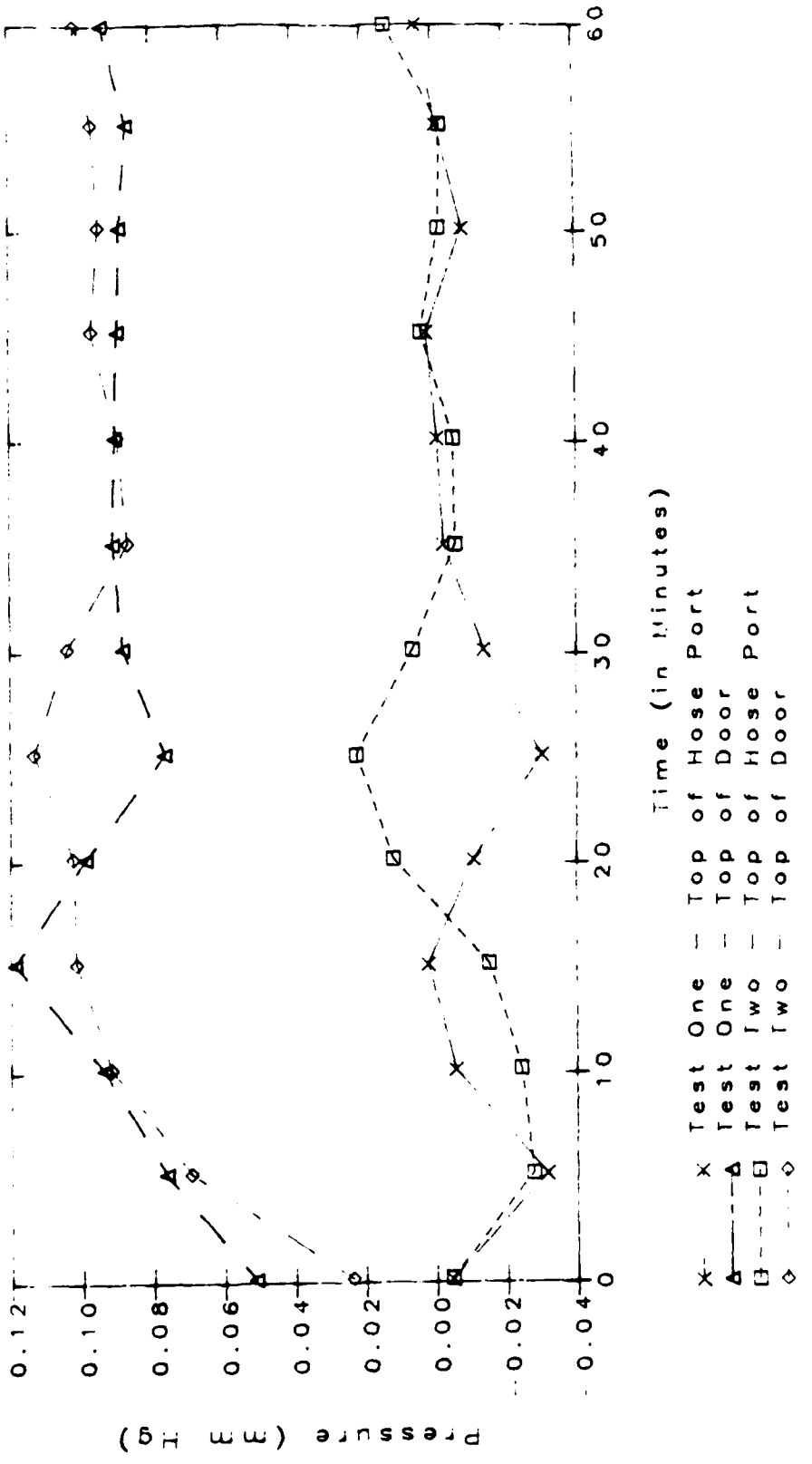
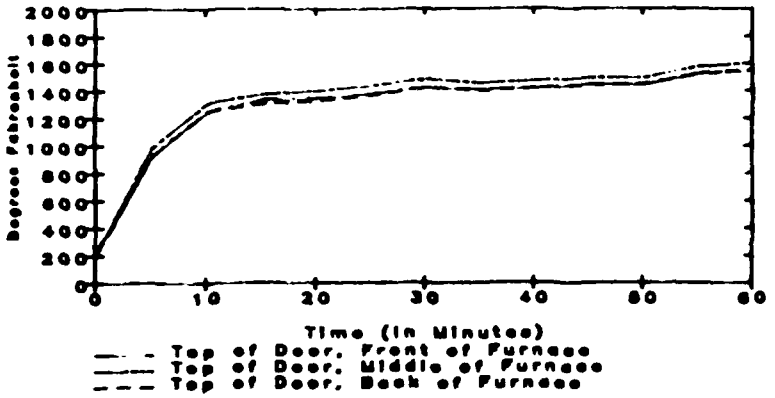
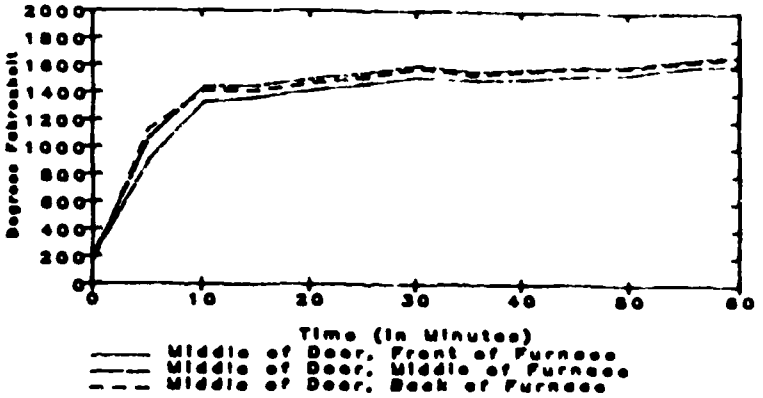


FIGURE 11. FURNACE PRESSURE





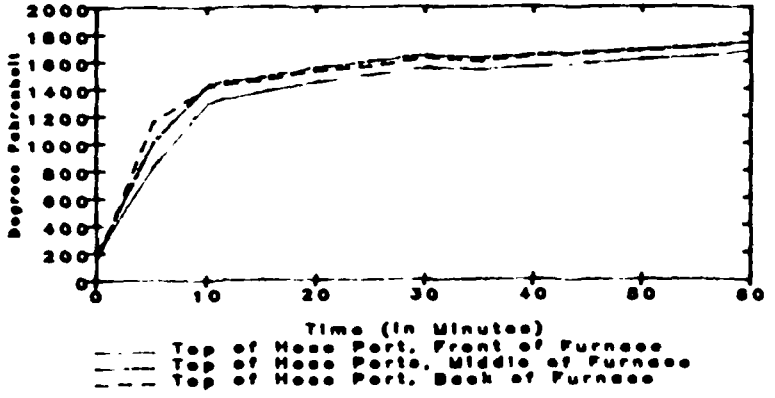


FIGURE 12. FURNACE TEMPERATURES, TEST 1

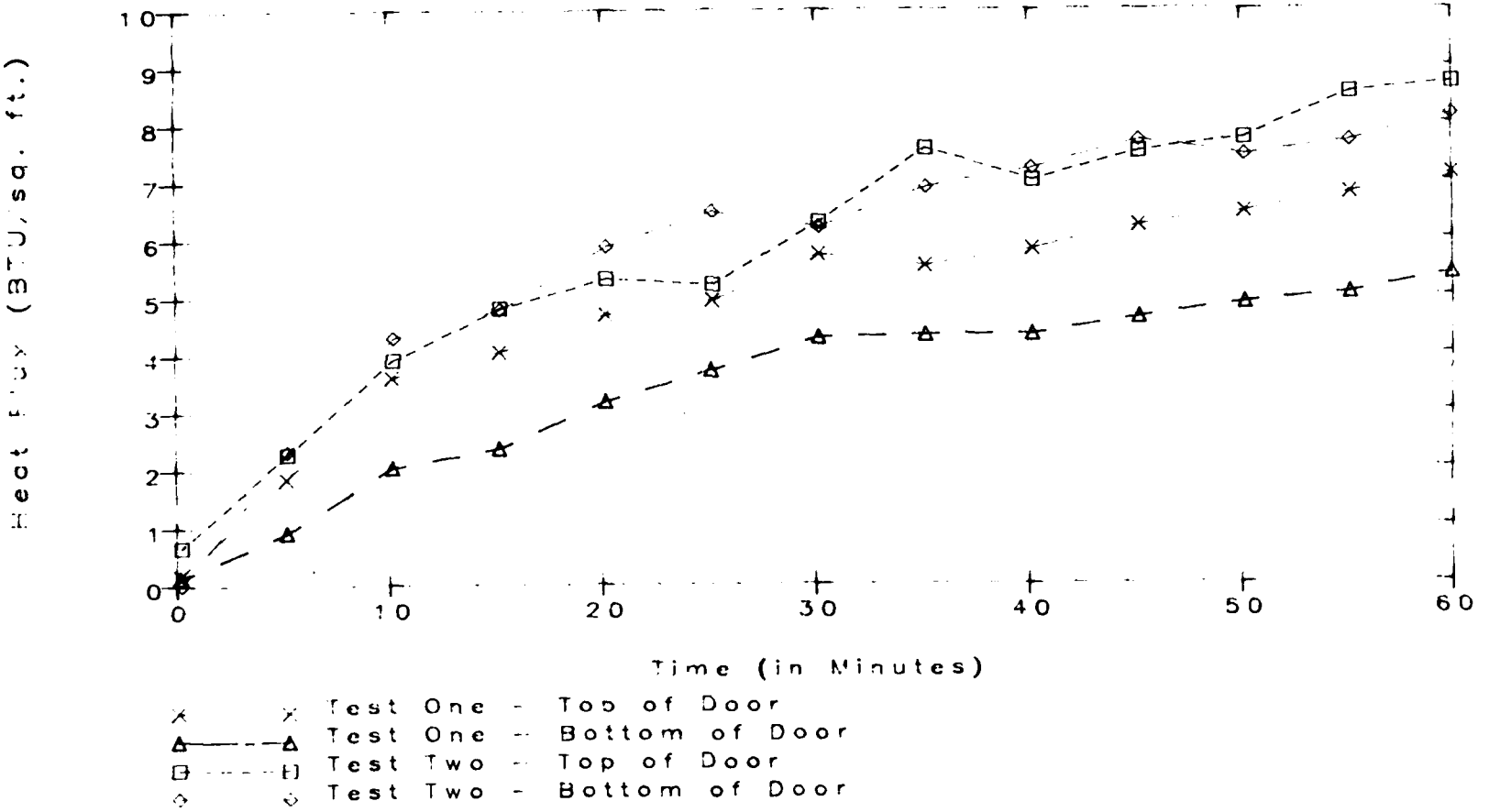
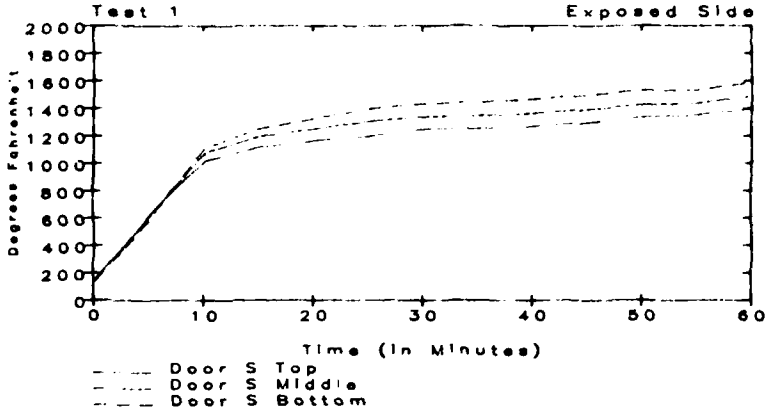
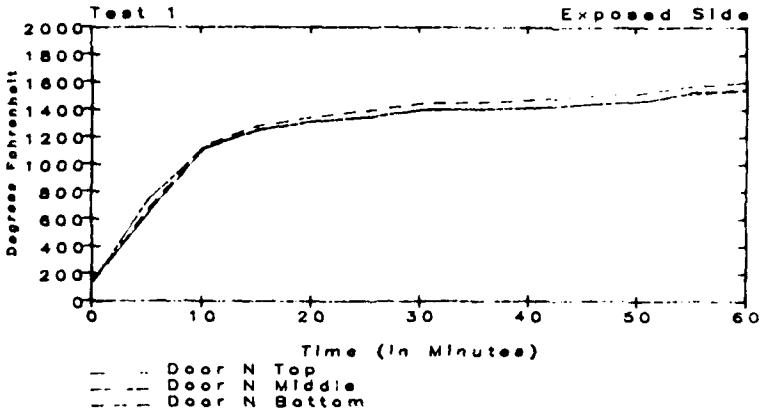
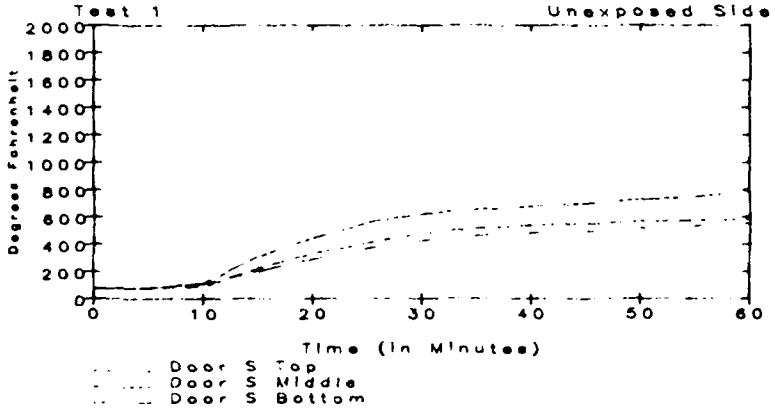


FIGURE 13. FURNACE HEAT FLUX







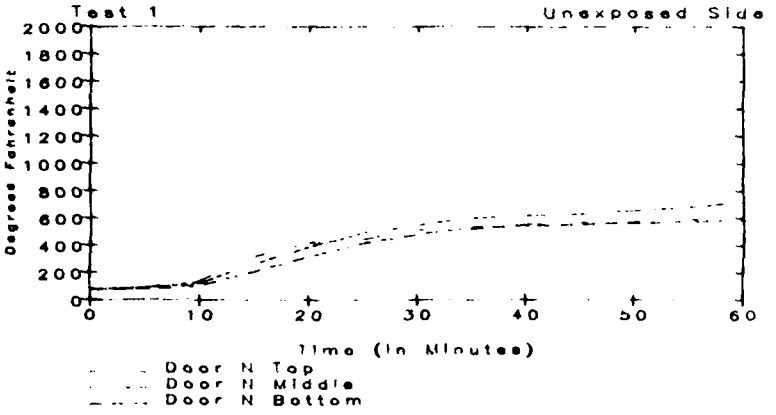
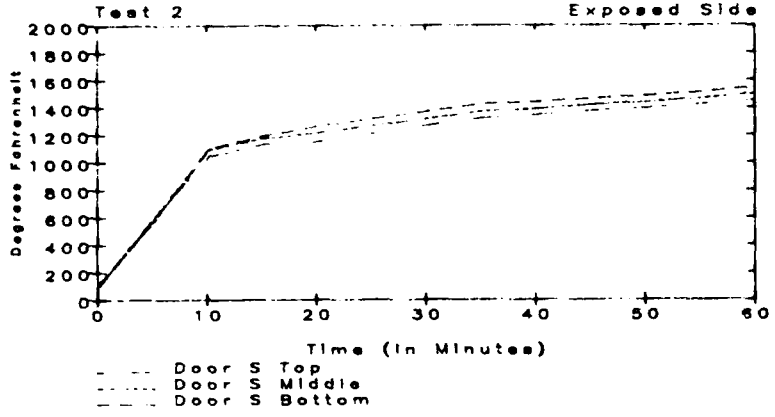
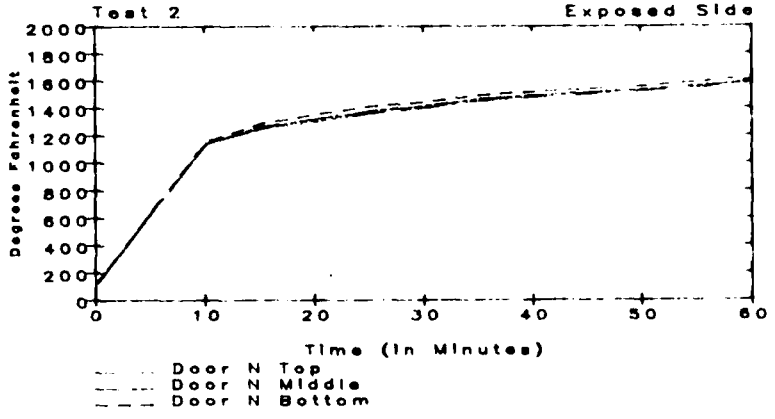
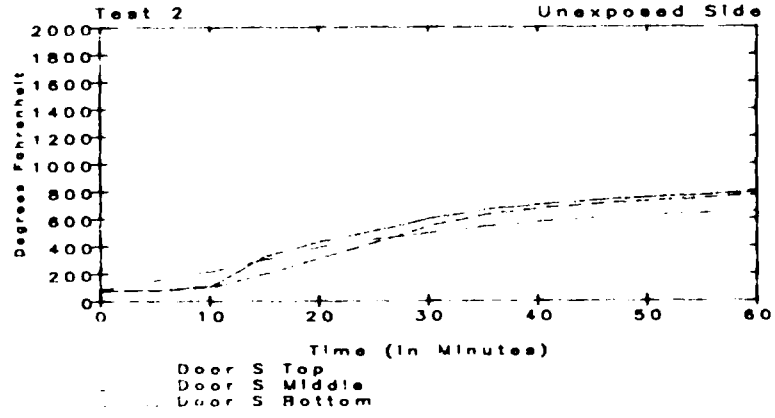


FIGURE 14. DOOR TEMPERATURES, TEST 1







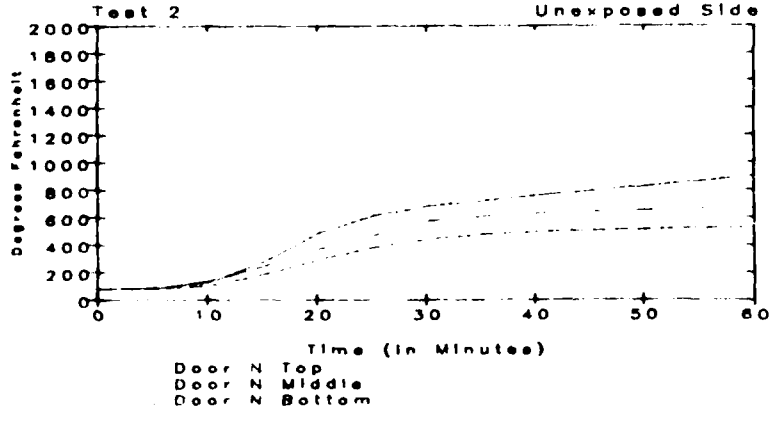


FIGURE 15. DOOR TEMPERATURES, TEST 2

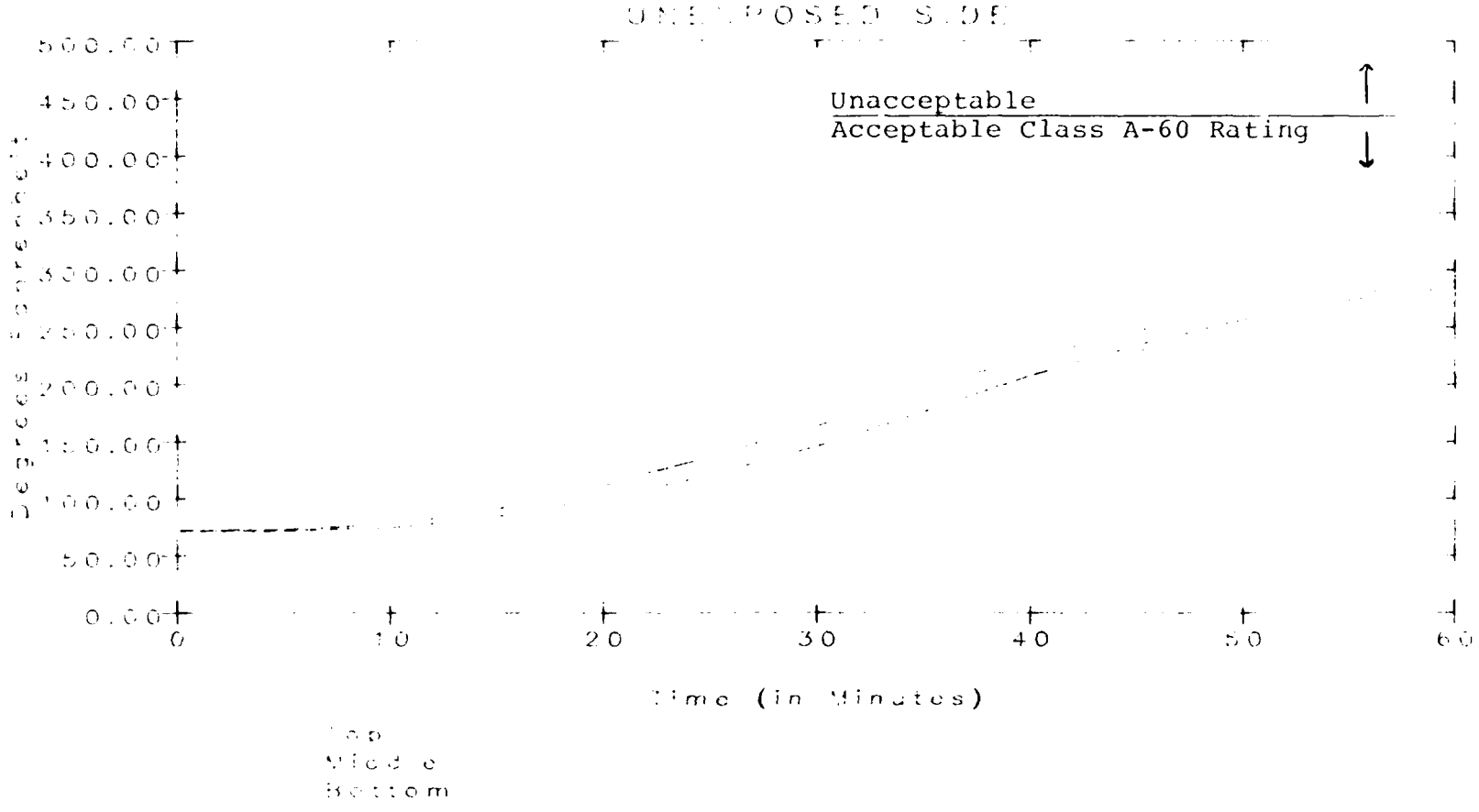


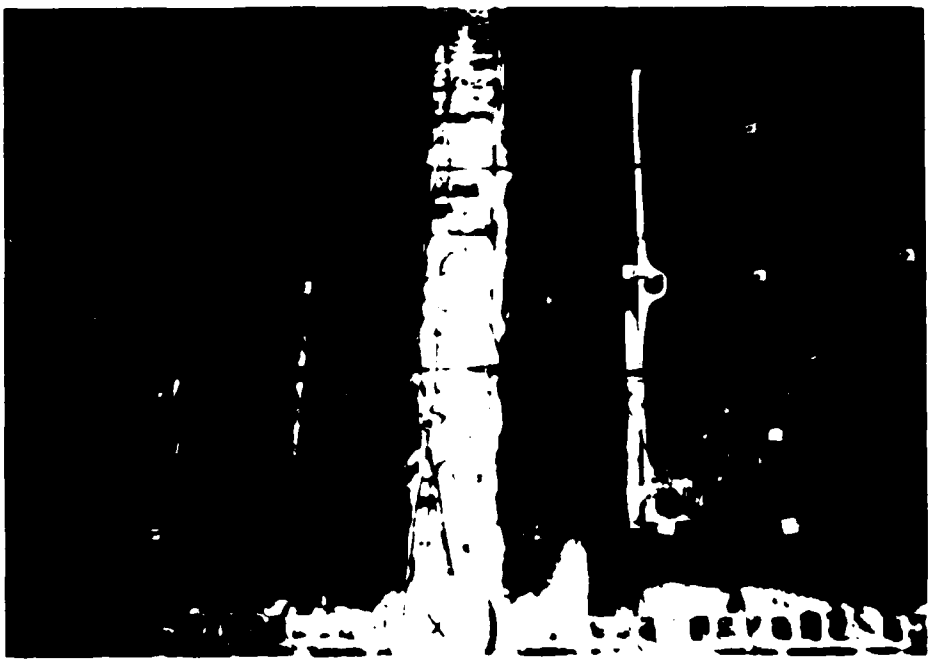
FIGURE 16. BULKHEAD TEMPERATURES

doors or the hose ports. Smoke began coming out of the area between the top of the doors and frames at approximately three to five minutes for all doors. Each door had smoke coming from the latch area by 12 minutes. The cotton-wool pads used in the flame tests became discolored or charred in all four tests. Only one cotton-wool pad ignited and that occurred in test one for the north door at test time 55 minutes. Flames were noted flickering through the latch area of both doors in test 1 at 40 minutes. The time of this flickering did not exceed five minutes. Figure 17 shows the condition of the fire door assemblies after the fire test and hose stream test.

Door movement measurements in table 1 show that none of the doors moved from their original position in the door frame beyond the acceptable limits of 1 3/4 inches (4.4 cm). Three of the doors did however fail the ASTM E152 acceptance standard by moving more than 1/2 inch (1.3 cm) at the latch location. The three doors which failed were inswinging doors. The door which did not fail at the latch area was an outswinging door. After the hose stream tests, movements were recorded for the doors and hose ports but the fire test results remained the same. None of the hose ports failed the movement standards. Figure 18 shows the expansion pattern associated with the outswinging and inswinging doors in the fire tests.

Temperatures histories between the doors and door frames are shown in figures 19 and 20 for the door assemblies. These figures show that the highest temperatures occurred at the latch and hinge area where the greatest movement of the doors took place. This movement is shown in table 1. It is interesting to note that the three doors which failed at the latch had temperatures at this point which ranged from 800 degrees F (425 degrees C) to 1200 degrees F (697 degrees C). The door which passed had temperatures at the latch which never reached 400 degrees F (205 degrees C). The door which recorded the lowest temperatures at the latch area was positioned to swing away from the furnace whereas the three doors which failed were positioned to swing into the furnace.

At no time did the temperatures measured between the hose ports and the doors exceed the temperatures measured between the doors and door frames of their respective doors. This is shown in figures 21, 22, and 23. In fact, all three hose ports had surrounding temperatures which were equal to or less than the temperatures surrounding the only door (the south door in test 2) to pass all the requirements for the ASTM E152 test. The temperatures surrounding the doors which failed were higher than those surrounding the door which passed. Figure 24 shows the condition of the hose ports after the testing.



UNEXPOSED SIDE

EXPOSED SIDE

FIGURE 17. FIRE DOOR ASSEMBLIES AFTER TESTING

TABLE

Test Run		20	40	55	After the Hose Stream Test
Test Run					
Door - South		1/8	1/8	1/8	1/16
-Test Line		1/8	1/8	1/8	1/8
-South Door	Latch area		3/16	3/16	1/8
-Door swings toward furnace	M5	1/8	1/8	1/8	3/16
	M6	3/8	3/8	3/8	0
-Hose Port	M7	3/8	3/8	3/8	0
Door - North	M1	1/8	1/8	1/8	1/16
-Test Line	M2	1/8	1/8	1/8	1/8
-North Door	Latch area	3/8	1/8	1/8	1/8
-Door swings toward furnace	M5	3/8	5/16	5/16	1/8
	M6	1/4	3/8	3/8	1/8
-Hose Port swings both toward and away from furnace	M7	3/16	3/8	3/8	1/8
Door - South	M1	1/16	1/8	1/8	0
-Test Two	M2	1/16	1/8	1/8	1/16
-South Door	M3	1/8	1/8	1/8	1/16
-Door swings away from furnace	M4	1/8	1/16	1/16	1/16
-Hose Port	M5	1/16	1/8	1/8	1/8
swings away	M6	0	1/8	3/16	1/16
from furnace	M7	0	0	0	1/16
Door - North	M1	1/16	1/8	1/8	1/16
-Test Two	M2	1/16	1/8	1/8	1/8
-North Door	M3	3/8	3/4	3/16	1/4
-Door swings toward furnace	M4	1/8	1/8	1/8	1/16
-Hose Port	M5	1/8	1/8	1/8	3/16
swings toward	M6	3/16	3/16	3/16	1/8
furnace	M7	5/16	5/16	5/16	1/4

* Movement of each door assembly was determined by measuring the initial position of the door to the frame and taking a new measurement at the same area at different times throughout the test. The differences of these two measurements indicated the total movement.

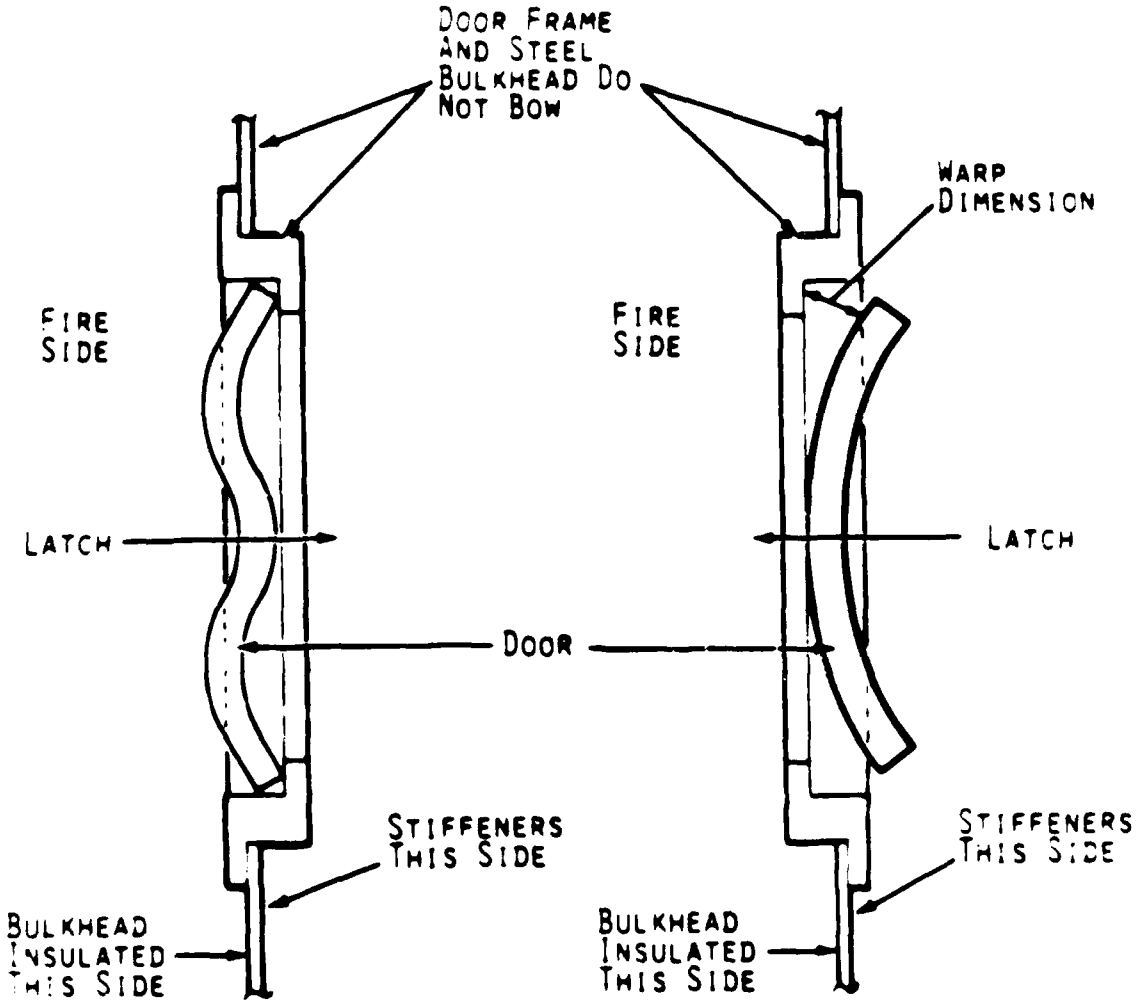
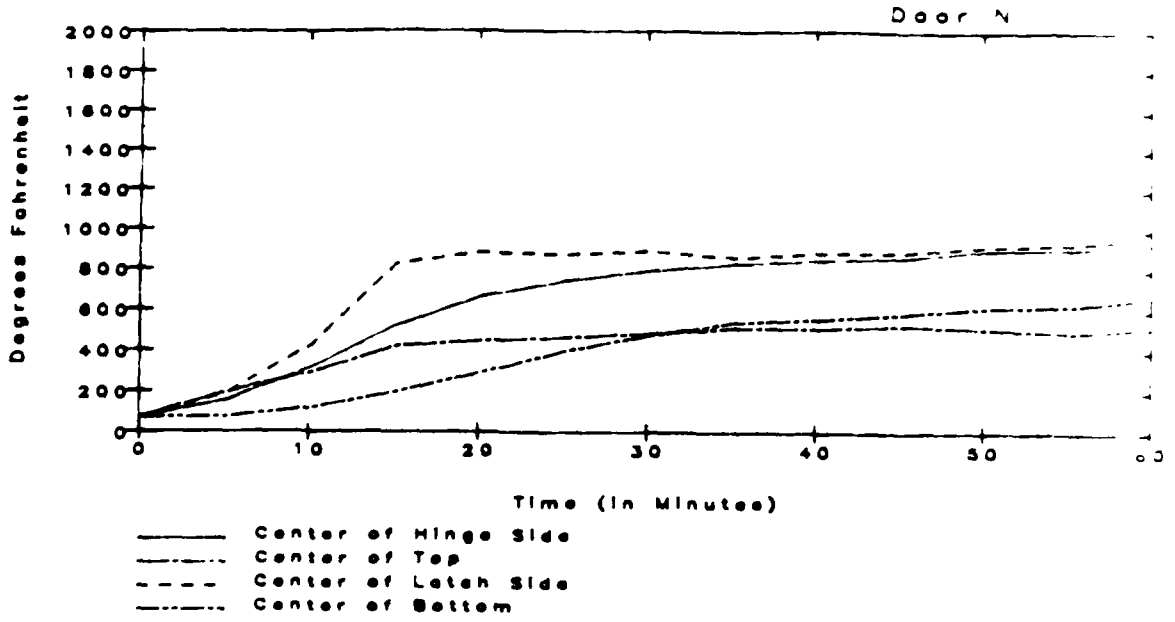


FIGURE 18. EXPANSION PATTERNS OF INSWINGING AND OUTSWINGING DOORS



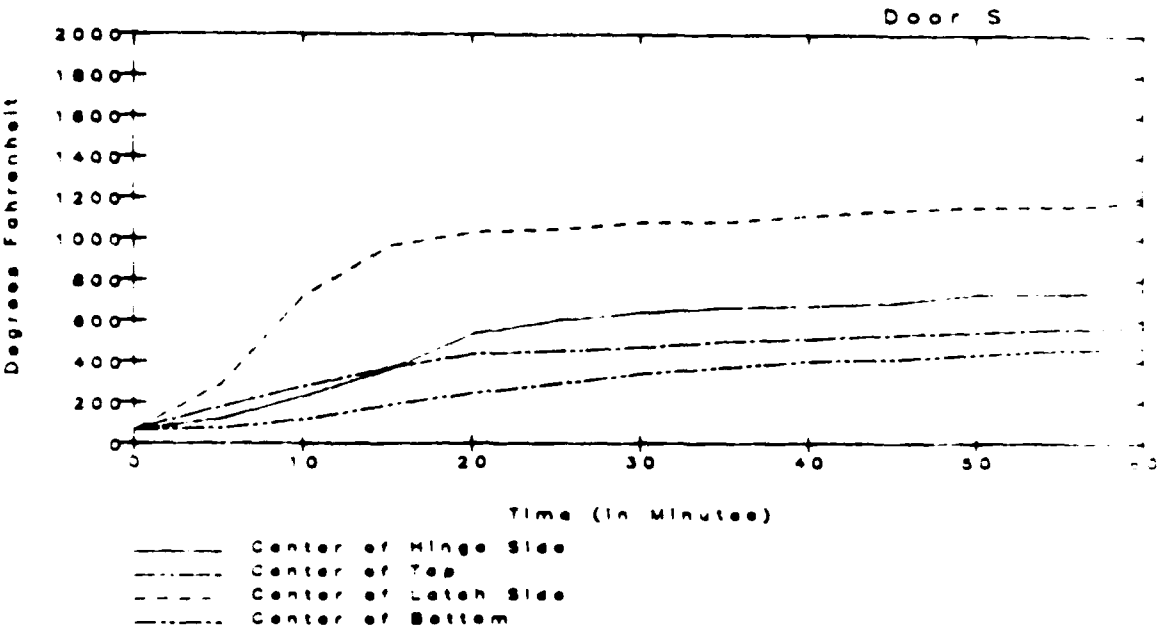
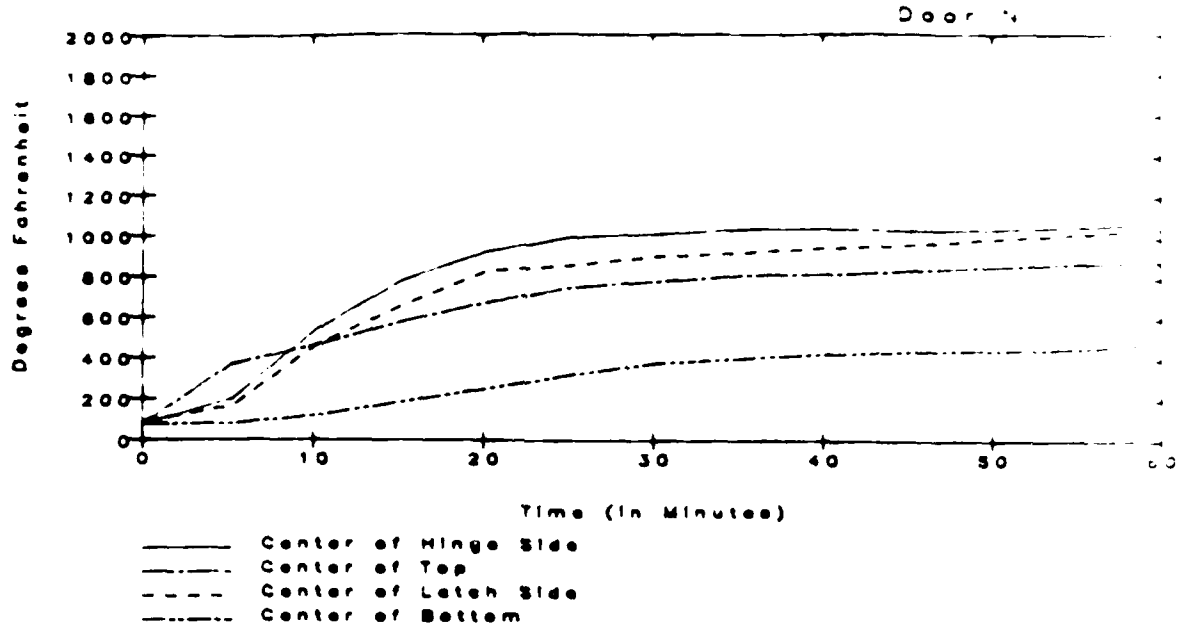


FIGURE 19. AIR TEMPERATURES BETWEEN DOOR AND DOOR FRAME, TEST 1



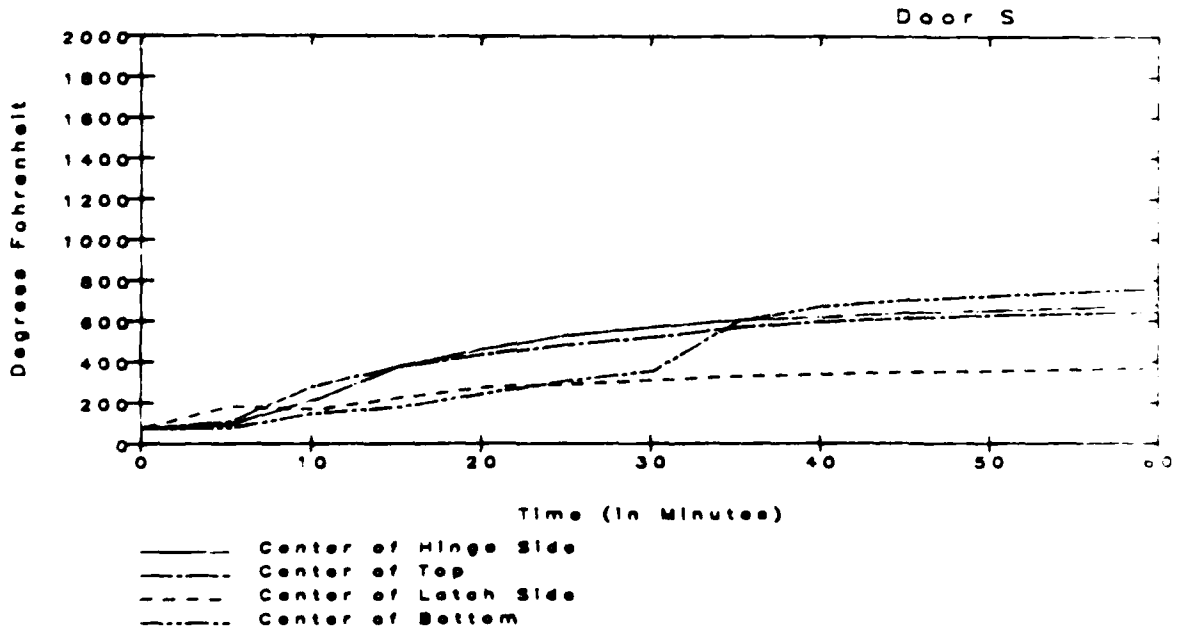
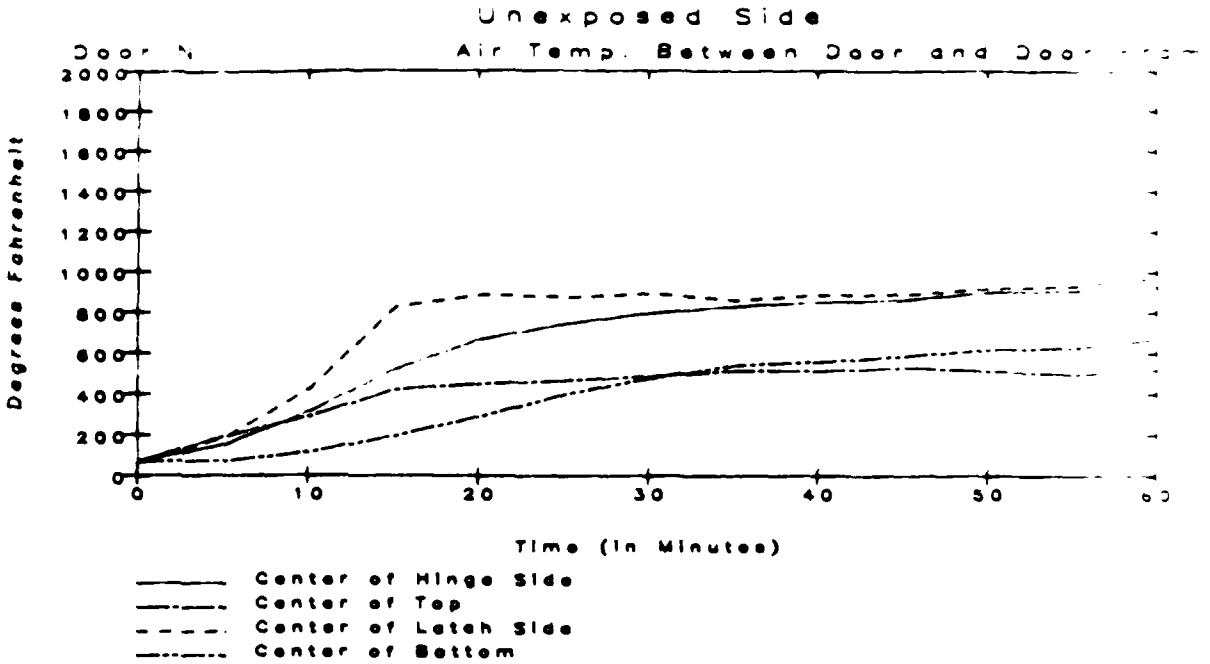


FIGURE 20. AIR TEMPERATURES BETWEEN DOOR AND DOOR FRAME, TEST 2



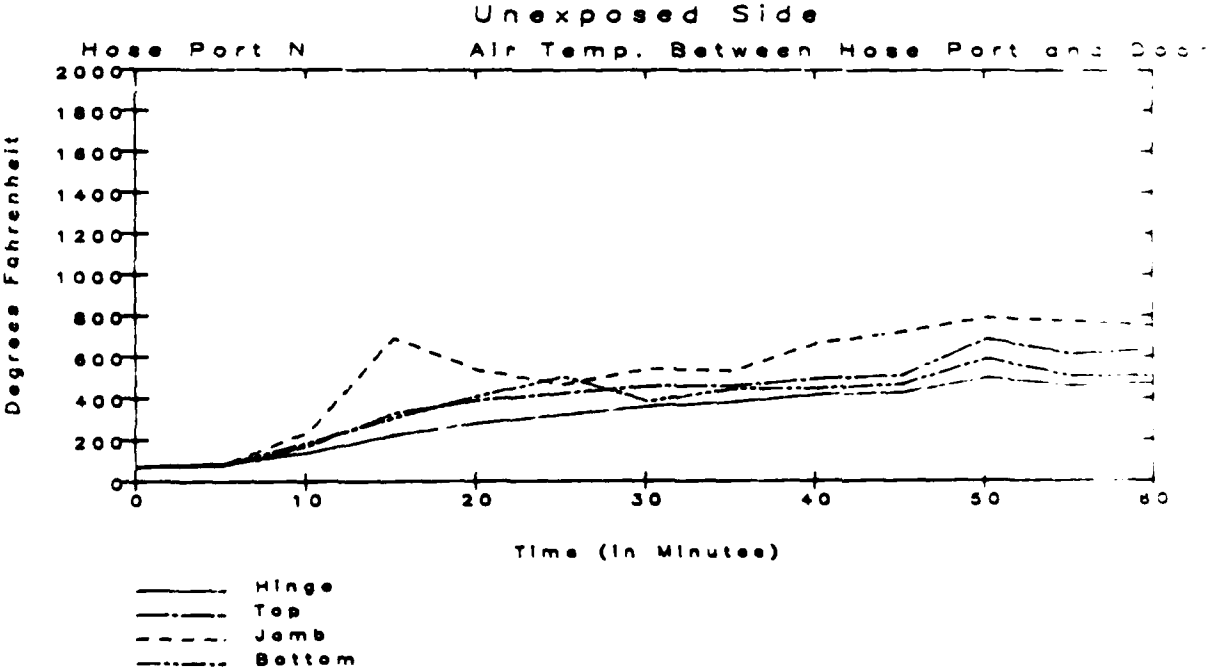
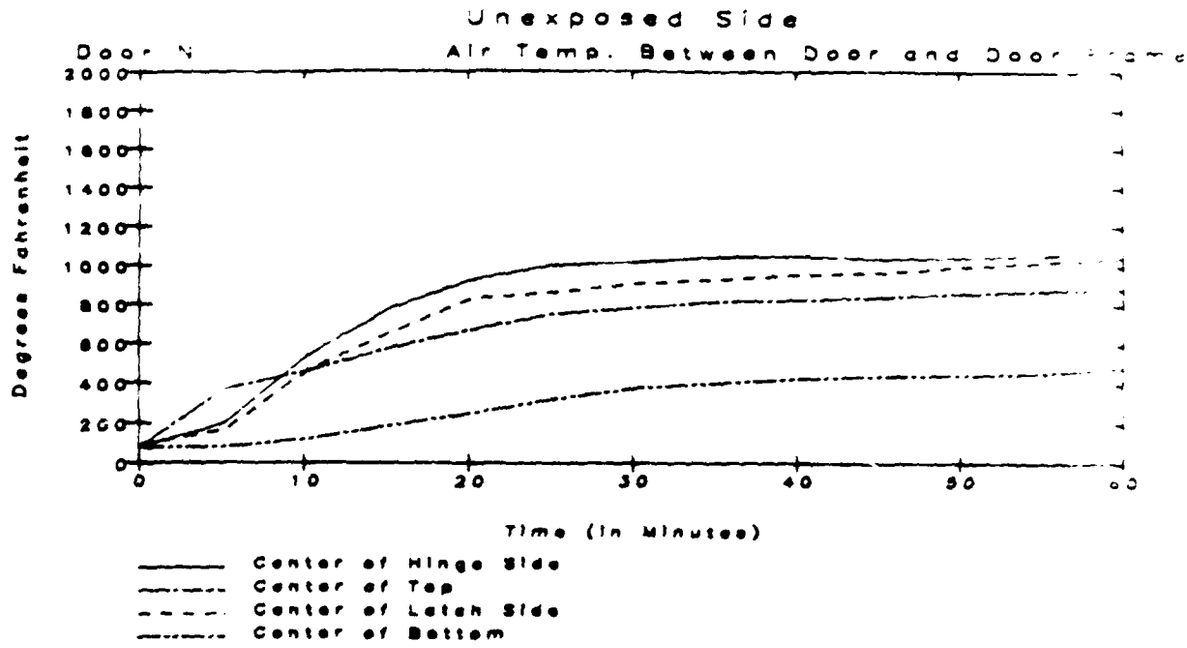


FIGURE 21. AIR TEMPERATURES, FIRE DOOR VS HOSE PORT TEST 1, NORTH DOOR



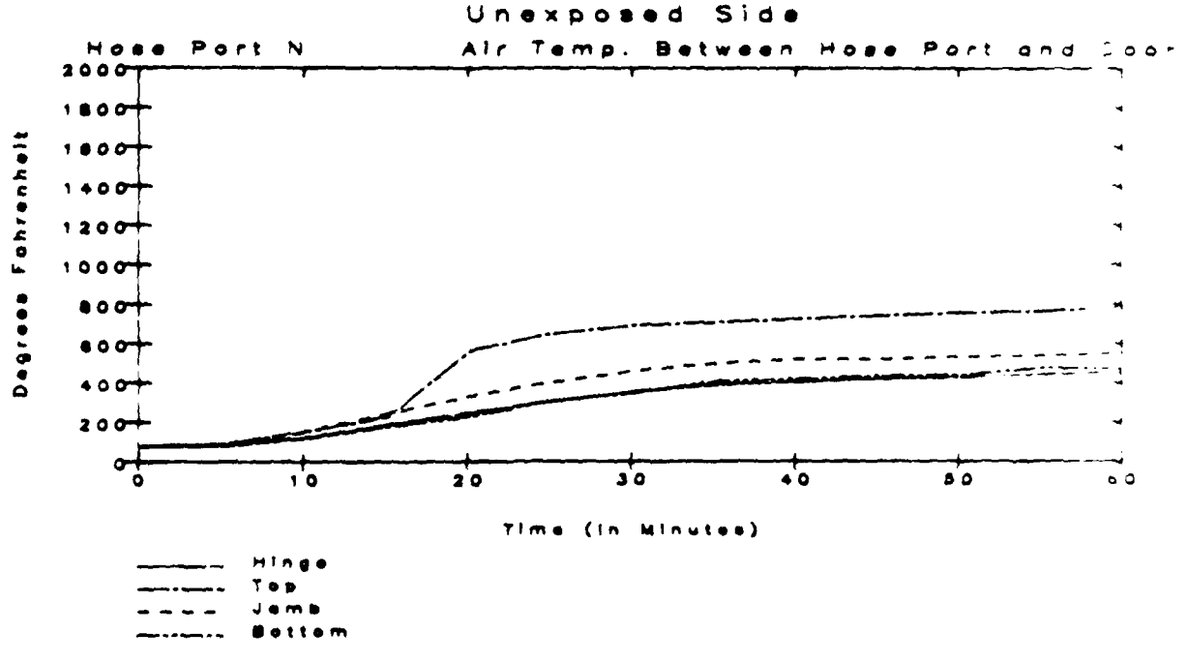
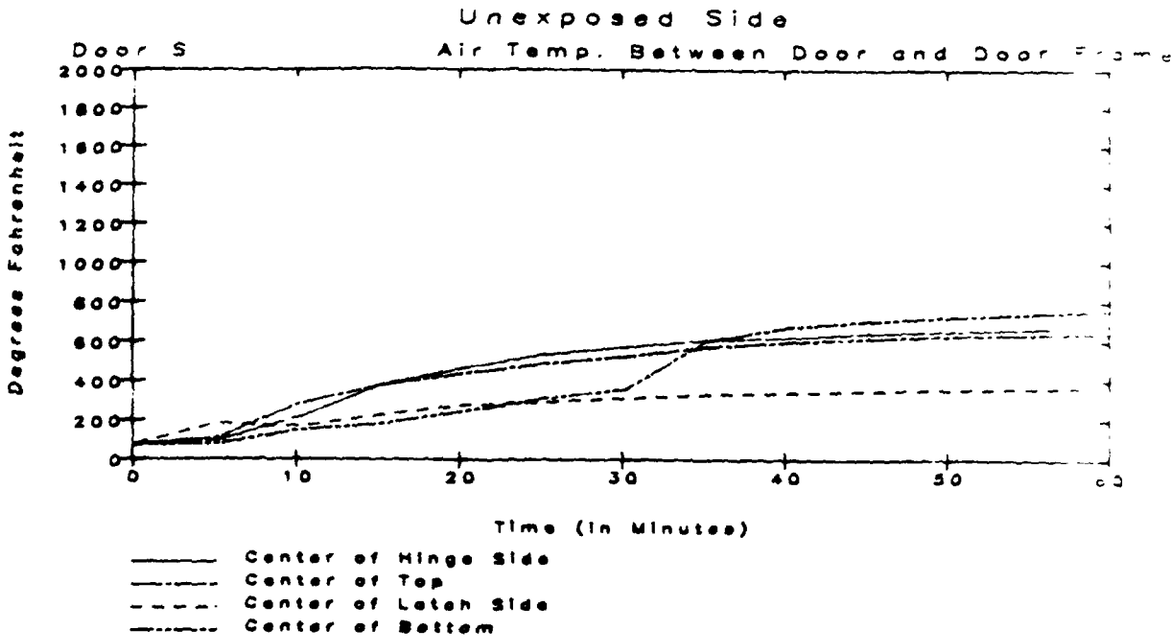


FIGURE 22. AIR TEMPERATURES, FIRE DOOR VS HOSE PORT
TEST 2, NORTH DOOR



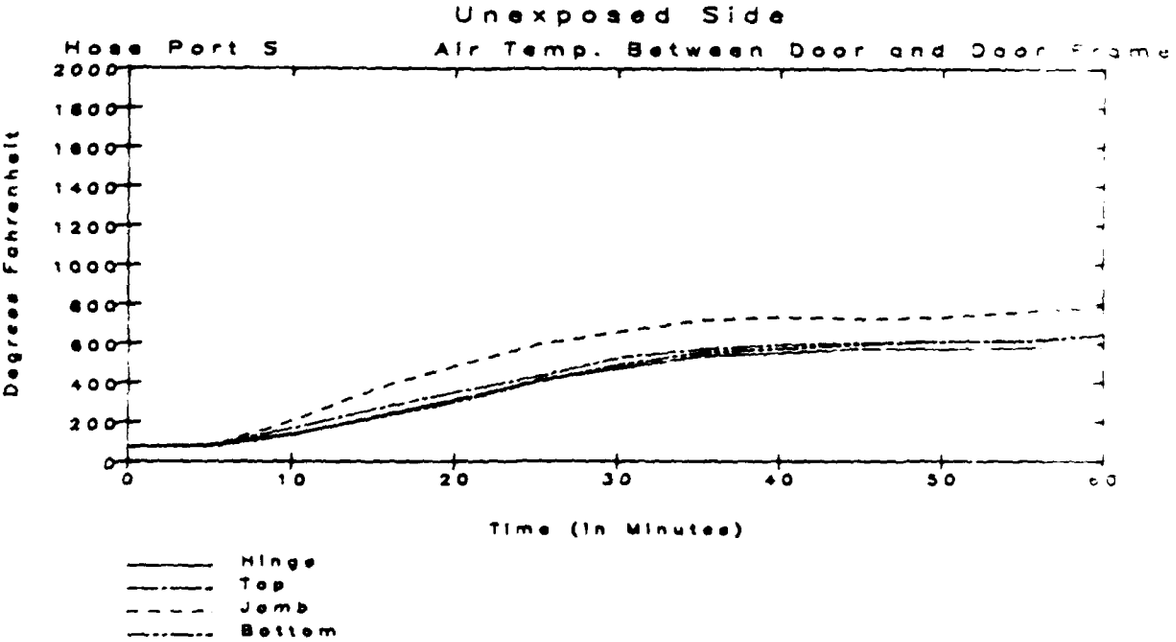


FIGURE 23. AIR TEMPERATURES, FIRE DOOR VS HOSE PORT
TEST 2, SOUTH DOOR

FIGURE 24. HOSE PORTS AFTER TESTING

8.0 CONCLUSIONS

a. The hose ports did not noticeably degrade the structural fire integrity of the fire doors.

b. The fire doors built to Coast Guard construction requirements failed the ASTM E152 fire test when positioned to swing into the furnace as the test procedure requires.

c. The fire door built to Coast Guard construction requirements passed the ASTM E152 fire test when positioned to swing away from the furnace.

d. In the ASTM E152 fire test, a door positioned to swing into the furnace is a more severe test setup than a door positioned to swing away from the furnace.

9.0 RECOMMENDATIONS

a. Hose ports should be used for all fire doors in passageways other than in watertight divisions.

b. Standard fire door tests should be conducted with doors swinging into the furnace to create a worse case test condition.

REFERENCES

1. Department of Transportation, Coast Guard, Specifications, Subchapter H (Title 46, CFR Part 72.05-25).

2. Department of Transportation, Coast Guard, Specifications, Subchapter Q (Title 46, CFR Part 164.008).

3. American Society For Testing and Materials. Standard Methods of Fire Tests of Building Construction and Materials, ASTM E-119-83, Annual Book of ASTM Standards, Vol. 04.07, 1983.

4. Navigation and Vessel Inspection Circular No. 6-80. Department of Transportation, U.S. Coast Guard.

5. Standard for Safety, Fire Tests of Door Assemblies, U.L. 10B, Underwriters Laboratories, Northbrook, Illinois, 1986.

6. International Maritime Organization, Fire Test Procedures, IMO, London 1984.

7. American Society For Testing and Materials. Standard Specifications for Doors and Frames, Steel, Interior Marine, ASTM F821-83, Annual Book of ASTM Standards. Vol. 04.07, 1983.

APPENDIX A

ASTM STANDARD E152-81a
STANDARD METHODS OF FIRE TESTS OF DOOR ASSEMBLIES

Designation: E 152 – 81a[ε1]

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia, Pa. 19103
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Standard Methods of FIRE TESTS OF DOOR ASSEMBLIES[1]

This standard is issued under the fixed designation E 152; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

These methods have been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

[ε1] NOTE—Paragraphs 10.2 and X1.13.1 were changed editorially and all references were renumbered in July 1984.

1. Scope

1.1 These methods of fire test are applicable to door assemblies of various materials and types of construction, for use in wall openings to retard the passage of fire (see commentary in Appendix).

1.2 Tests made in conformity with these test methods will register performance during the test exposure; but such tests shall not be construed as determining suitability for use after exposure to fire.

1.3 It is the intent that tests made in conformity with these test methods will develop data to enable regulatory bodies to determine the suitability of door assemblies for use in locations where fire resistance of a specified duration is required.

1.4 *This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elemens of a fire risk assessment which takes into account all of the factors which are pertinent in an assessment of the fire hazard of a particular end use.*

2. Significance

2.1 These methods are intended to evaluate the ability of a door assembly to remain in an opening during a predetermined test exposure.

2.2 The tests expose a specimen to a standard fire exposure controlled to achieve specified temperatures throughout a specified time period, followed by the application of a specified standard fire host stream. The exposure, however, may not be representative of all fire conditions, which may vary with changes in the amount, nature, and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. It does, however, provide a relative measure of fire performance of door assemblies under these specified fire exposure conditions.

2.3 Any variation from the construction or conditions that are tested may substantially change the performance characteristics of the assembly.

2.4 The methods do not provide the following:

2.4.1 Full information as to performance of all door assemblies in walls constructed of materials other than that tested.

2.4.2 Evaluation of the degree by which the door assembly contributes to the fire hazard by generation of smoke, toxic gases, or other products of combustion.

2.4.3 A specific requirement that the unexposed surface temperatures be reported although the temperature measurement procedure is described.

2.4.4 A limit on the number of openings allowed in glazed areas or of the number and size of lateral openings between the door and frame.

2.4.5 Measurement of the degree of control or limitation of the passage of smoke or prod-

[1] These methods are under the jurisdiction of ASTM Committee E-5 on Fire Standards.

Current edition approved Sept. 25 and Nov. 30, 1981. Published March 1982. Originally published as C 152 – 40 T. Redesignated E 152 in 1941. Last previous edition E 152 – 80.

ucts of combustion through the door assembly.

CONTROL OF FIRE TESTS

3. Time - Temperature Curve

3.1 The fire exposure of door assemblies shall be controlled to conform to the applicable portion of the standard time - temperature curve shown in Fig. 1. The points on the curve that determine its character are:

1000°F (538°C)	at 5 min
1300°F (704°C)	at 10 min
1550°F (843°C)	at 30 min
1700°F (926°C)	at 1 h
1850°F (1010°C)	at 2 h
2000°F (1093°C)	at 4 h
2300°F (1260°C)	at 8 h or over

3.1.1 For a closer definition of the time - temperature curve, see Table A1.1.

4. Furnace Temperatures

4.1 The temperatures of the test exposure shall be deemed to be the average temperature obtained from the readings of not less than nine thermocouples symmetrically disposed and distributed to show the temperature near all parts of the test assembly. The thermocouples shall be protected by sealed porcelain tubes having ¾-in. (19-mm) outside diameter and ⅛-in. (3-mm) wall thickness, or, as an alternative, in the case of base metal thermocouples, protected by ½-in. (13-mm) wrought steel or wrought iron pipe of standard weight. The junction of the thermocouples shall be 6 in. (152 mm) from the exposed face of the test assembly or from the masonry in which the assembly is installed, during the entire test exposure.

4.2 The temperatures shall be read at intervals not exceeding 5 min during the first 2 h, and thereafter the intervals may be increased to not more than 10 min.

4.3 The accuracy of the furnace control shall be such that the area under the time - temperature curve, obtained by averaging the results from the thermocouple readings, is within 10 % of the corresponding area under the standard time - temperature curve for fire tests of 1 h or less duration, within 7.5 % for those over 1 h and not more than 2 h, and within 5 % for tests exceeding 2 h in duration.

5. Unexposed Surface Temperatures

5.1 Unexposed surface temperatures shall be recorded and shall be determined in the following manner:

5.1.1 Unexposed surface temperatures shall be taken at not less than three points with at least one thermocouple in each 16 ft^2 (1.5 m^2) area of the door. Thermocouples shall not be located over reinforcements extending through the door, over vision panels, or nearer than 12 in. (305 mm) from the edge of the door.

5.1.2 Unexposed surface temperatures shall be measured with thermocouples placed under flexible, oven-dry, felted asbestos pads 6 in. (152 mm) square, 0.4 in. (10 mm) in thickness, and weighing not less than 1.0 nor more than 1.4 lb/ft^2 (4.88 to 6.83 kg/m^2). The pads shall be held firmly against the surface of the door and fit closely about the thermocouples. The thermocouple leads shall be immersed under the pad for a distance of not less than 3½ in. (89 mm) with the hot junction under the center of the pad. The thermocouple leads under the pads shall be not heavier than No. 18 B & S gage (0.04 in.) (1.02 mm) and shall be electrically insulated with heat-resistant and moisture-resistant coatings.

5.1.3 Unexposed surface temperatures shall be read at intervals not exceeding 5 min for the first 30 min of the test.

TEST ASSEMBLIES

6. Construction and Size

6.1 The construction and size of the test door assembly, consisting of single doors, doors in pairs, special-purpose doors (such as Dutch doors, double-egress doors, etc.), or multisection doors, shall be representative of that for which classification or rating is desired.

6.2 A floor structure shall be provided as part of the opening to be protected, except where such floor interferes with the operation of the door. The floor segment shall be of noncombustible material and shall project into the furnace approximately twice the thickness of the test door, or to the limit of the frame, whichever is greater.

7. Mounting for Test

7.1 Swinging doors shall be mounted so as to open into the furnace chamber. Sliding and rolling doors, except horizontal slide-type elevator shaft doors, shall be mounted on the exposed side of the opening in the wall closing the furnace chamber. Horizontal slide-type elevator shaft doors shall be mounted on the unexposed side of the opening in the wall closing the furnace chamber. Access-type doors

and chute-type doors and frame assemblies shall be mounted so as to have one assembly open into the furnace chamber and another assembly open away from the furnace chamber. Dumb-waiter and service-counter doors and frame assemblies shall be mounted on the exposed side of the opening in the wall.

7.2 The mounting of all doors shall be such that they fit snugly within the frame, against the wall surfaces, or in guides, but such mounting shall not prevent free and easy operation of the test door.

7.2.1 Clearances for swinging doors shall be as follows: With a minus 1/16-in. (1.6-mm) tolerance: 1/8 in. (3.2 mm) along the top, 1/8 in. along the hinge and latch jambs, 1/8 in. along the meeting edge of doors, in pairs, and 3/8 in. (9.5 mm) at the bottom edge of a single swinging door, and 1/4 in. (6.3 mm) at the bottom of a pair of doors.

7.2.2 Clearances of horizontal sliding doors not mounted within guides shall be as follows: With a minus 1/8-in. (3.2-mm) tolerance: 1/2 in. (12.7 mm) between the door and wall surfaces, 1/8 in. (9.5 mm) between the door and floor structure and 1/4 in. (6.3 mm) between the meeting edges of center-parting doors. A maximum lap of 4 in. (102 mm) of the door over the wall opening at sides and top shall be provided.

7.2.3 Clearances of vertical sliding doors moving within guides shall be as follows: With a minus 1/8-in. (3.2-mm) tolerance: 1/2 in. (12.7 mm) between the door and wall surfaces along the top and/or the bottom door edges with guides mounted directly to the wall surfaces and 3/16 in. (4.8 mm) between the meeting edges of bi-parting doors or 1/16 in. between the door and floor structure or the sill.

7.2.4 Clearances for horizontal slide type elevator doors shall be as follows: With a minus 1/8-in. (3.2-mm) tolerance: 1/8 in. (9.5 mm) between the door and wall surfaces, 1/8 in. between the multisection door panels, and 1/8 in. from the bottom of a panel to the sill. Multisection door panels shall overlap 1/4 in. (19.0 mm). Door panels shall lap the wall opening 1/4 in. at the sides and top.

CONDUCT OF TESTS

8. Time of Testing

8.1 *Time of Testing*—Masonry shall have sufficient strength to retain the assembly securely in position throughout the fire and hose stream test.

9. Fire Endurance Test

9.1 Maintain the pressure in the furnace chamber as nearly equal to the atmospheric pressure as possible.

9.2 Continue the test until the exposure period of the desired classification or rating is reached unless the conditions of acceptance set forth in Section 12 are exceeded in a shorter period.

10. Hose Stream Test

10.1 Immediately following the fire endurance test, subject the test assembly to the impact, erosion, and cooling effects of a hose stream directed first at the middle and then at all parts of the exposed surface, making changes in direction slowly.

10.2 Deliver the hose stream through a 2 1/2-in. (64-mm) hose discharging through a National Standard Playpipe of corresponding size equipped with a 1 1/8-in. (28.5-mm) discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure at the base of the nozzle and duration of application in s/ft^2 (m^2) of exposed area shall be as prescribed in Table 1.

10.3 The tip of the nozzle shall be located 20 ft (6 m) from and on a line normal to the center of the test door. If impossible to be so located, the nozzle may be on a line deviating not to exceed 30° from the line normal to the center of the test door. When so located the distance from the center shall be less than 20 ft by an amount equal to 1 ft (0.3 m) for each 10° of deviation from the normal.

11. Report

11.1 Report results in accordance with the performance in the tests prescribed in these test methods. The report shall show:

11.1.1 The performance under the desired exposure period chosen from the following: 20 min, 30 min, 1/4 h, 1 h, 1 1/2 h, or 3 h.

11.1.2 The temperature measurements of the furnace.

11.1.3 The temperature measurement of the unexposed side.

11.1.4 All observations having a bearing on the performance of the test assembly.

11.1.5 Flaming, if any, on the unexposed surface of the door leaf during the first 20 min of the fire test.

11.1.6 The amount of movement of any portion of the edges of the door adjacent to the door frame from the original position (see Section 12).

11.1.7 The materials and the construction of the door and frame, and the details of the installation, hardware, hangers, guides, trim, finish, and clearance or lap shall be recorded or appropriately referenced to ensure positive identification or duplication in all respects.

11.1.8 Pressure measurements made in the furnace and their relationship to the top of the door.

CONDITIONS OF ACCEPTANCE

12. Conditions of Acceptance

12.1 A door assembly shall be considered as meeting the requirements for acceptable performance when it remains in the opening during the fire endurance test and host-stream test within the following limitations:

12.1.1 The movement of swinging doors shall not permit any portion of the edges to move from the original position more than the thickness of the door, during the first half of the classification period, nor more than 1½ times the thickness during the entire classification period, nor more than 1½ times the thickness immediately following the hose stream test.

12.1.2 An assembly consisting of a pair of swinging doors shall not separate more than ¾ in. (19 mm) or equal to the throw of the latch bolt at the latch location.

12.1.3 An assembly consisting of a single swinging door shall not separate more than in. (13 mm) at the latch location.

12.1.4 The lap edges of passenger (A17.1 horizontal slide-type) elevator doors, including the lap edges of multisection doors, shall not move from the wall or adjacent panel surfaces sufficiently to develop a separation of more than 2⅞ in. (73.0 mm) during the entire classification period, or immediately following the hose stream test. The meeting edges of center-parting elevator door assemblies, for a fire and hose stream exposure of 1½ h or less, shall not move apart more than 1¼ in. (31.7 mm) as measured in any horizontal plane during the entire classification period or immediately following the hose stream test.

12.1.5 Doors mounted in guides shall not release from guides and guides shall not loosen from fastenings.

12.1.6 The test assembly shall have withstood the fire endurance test and hose-stream test, without developing openings anywhere through the assembly, except that small portions of glass dislodged by the hose stream shall not be considered a weakness.

13. Precision and Bias

13.1 Precision and bias data are not available at this time; however, a task group of Subcommittee E05.12 has been established to investigate the subject and prepare a statement.

TABLE 1 Water Pressure at Base of Nozzle and Duration of Application[A]

Desired Rating	Water Pressure at Base of Nozzle, psi (kPa)	Duration of Application, s/ft² (0.09 m²) exposed area
3 h	45 (310)	3
1½ h and over if less than 3 h	30 (207)	1.5
1 h and over if less than 1½ h	30 (207)	0.9
Less than 1 h	30 (207)	0.6

[A] The exposed area may be calculated using the outside dimensions of the test specimen, including a frame, hangers, tracks, or other parts of the assembly if provided, but normally not including the wall into which the specimen is mounted. Where multiple test specimens are mounted in the same wall, the rectangular or square wall area encompassing all of the specimens will have to be considered as the exposed area since the hose stream must traverse this area during its application.

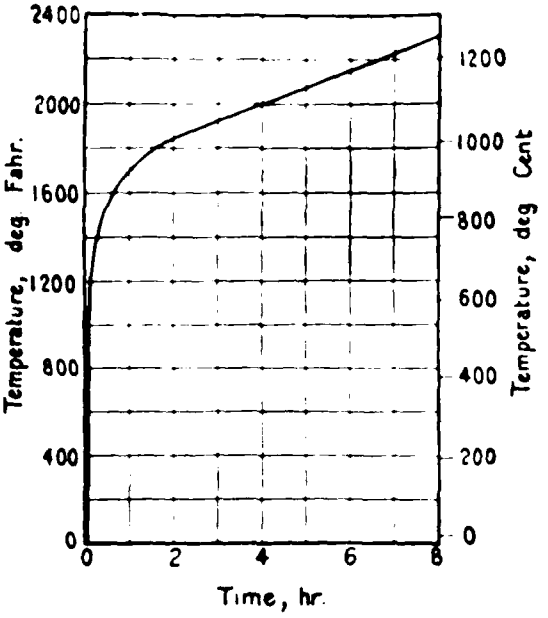

FIG. 1 Time - Temperature Curve

ANNEX

(Mandatory Information)

TABLE A1.1 Standard Time-Temperature Curve for Control of Fire Tests

Time	Temperature, °F	Area Above 68°F Base		Temperature, °C	Area Above 20°C Base	
h min		°F-min	°F-h		°C-min	°C-h
0 00	68	00	0	20	00	0
0 05	1 000	2 330	39	538	1 290	22
0 10	1 300	7 740	129	704	4 300	72
0 15	1 399	14 150	236	760	7 860	131
0 20	1 462	20 970	350	795	11 650	194
0 25	1 510	28 050	468	821	15 590	260
0 30	1 550	35 360	589	843	19 650	328
0 35	1 584	42 860	714	862	23 810	397
0 40	1 613	50 510	842	878	28 060	468
0 45	1 638	58 300	971	892	32 390	540
0 50	1 661	66 200	1 103	905	36 780	613
0 55	1 681	74 220	1 237	916	41 230	687
1 00	1 700	82 330	1 372	927	45 740	762
1 05	1 718	90 540	1 509	937	50 300	838
1 10	1 735	98 830	1 647	946	54 910	915
1 15	1 750	107 200	1 787	955	59 560	993
1 20	1 765	115 650	1 928	963	64 250	1 071
1 25	1 779	124 180	2 070	971	68 990	1 150
1 30	1 792	132 760	2 213	978	73 760	1 229
1 35	1 804	141 420	2 357	985	78 560	1 309
1 40	1 815	150 120	2 502	991	83 400	1 390
1 45	1 826	158 890	2 648	996	88 280	1 471
1 50	1 835	167 700	2 795	1 001	93 170	1 553
1 55	1 843	176 550	2 942	1 006	98 080	1 635
2 00	1 850	185 440	3 091	1 010	103 020	1 717
2 10	1 862	203 330	3 389	1 017	112 960	1 882
2 20	1 875	221 330	3 689	1 024	122 960	2 049
2 30	1 888	239 470	3 991	1 031	133 040	2 217
2 40	1 900	257 720	4 295	1 038	143 180	2 386
2 50	1 912	276 110	4 602	1 045	153 390	2 556
3 00	1 925	294 610	4 910	1 052	163 670	2 728
3 10	1 938	313 250	5 221	1 059	174 030	2 901
3 20	1 950	332 000	5 533	1 066	184 450	3 074
3 30	1 962	350 890	5 848	1 072	194 940	3 249
3 40	1 975	369 890	6 165	1 079	205 500	3 425
3 50	1 988	389 030	6 484	1 086	216 130	3 602
4 00	2 000	408 280	6 805	1 093	226 820	3 780
4 10	2 012	427 670	7 128	1 100	237 590	3 960
4 20	2 025	447 180	7 453	1 107	248 430	4 141
4 30	2 038	466 810	7 780	1 114	259 340	4 322
4 40	2 050	486 560	8 110	1 121	270 310	4 505
4 50	2 062	506 450	8 441	1 128	281 360	4 689
5 00	2 075	526 450	8 774	1 135	292 470	4 874
5 10	2 088	546 580	9 110	1 142	303 660	5 061
5 20	2 100	566 840	9 447	1 149	314 910	5 249
5 30	2 112	587 220	9 787	1 156	326 240	5 437
5 40	2 125	607 730	10 129	1 163	337 630	5 627
5 50	2 138	628 360	10 473	1 170	349 090	5 818
6 00	2 150	649 120	10 819	1 177	360 620	6 010
6 10	2 162	670 000	11 167	1 184	372 230	6 204

TABLE A1.1 *Continued*

Time	Temperature, °F	Area Above 68°F Base		Temperature, °C	Area Above 20°C Base	
h min		°F-min	°F-h		°C-min	°C-h
6 20	2 175	691 010	11 517	1 191	383 900	6 398
6 30	2 188	712 140	11 869	1 198	395 640	6 594
6 40	2 200	733 400	12 223	1 204	407 450	6 791
6 50	2 212	754 780	12 580	1 211	419 330	6 989
7 00	2 225	776 290	12 938	1 218	431 270	7 188
7 10	2 238	797 920	13 299	1 225	443 290	7 388
7 20	2 250	819 680	13 661	1 232	455 380	7 590
7 30	2 262	841 560	14 026	1 239	467 540	7 792
7 40	2 275	863 570	14 393	1 246	479 760	7 996
7 50	2 288	885 700	14 762	1 253	492 060	8 201
8 00	2 300	907 960	15 133	1 260	504 420	8 407

APPENDIX

(Nonmandatory Information)

X1. COMMENTARY

X1.1 Introduction

X1.1.1 This commentary has been prepared to provide the user of Methods E 152 with background information on the development of the standard and its application in fire protection of buildings. It also provides guidance in the planning and performance of fire tests and in the reporting of results. No attempt has been made to incorporate all of the available information on fire testing in this commentary. The serious student of fire testing is strongly urged to peruse the referenced documents for a better appreciation of the history of fire-resistant design and the intricate problems associated with testing and with interpretation of test results.

X1.2 Application

X1.2.1 Compartmentation of buildings by fire-resistive walls has been recognized for many years as an efficient method of restricting fires to the area of origin (**1, 2, 3, 4, 5, 6, 7, 8, 9**)[2] or limiting their spread. The functional use of buildings however, demands a reasonable amount of communication between compartments necessitating openings in these fire-resistive walls. Fire door assemblies are utilized to protect these openings and maintain the integrity of the fire barrier (**10**). Openings in walls have been classified by fire protection standards (**6, 11, 12**) and building codes in accordance with the location and purpose of the wall in which the opening occurs, and these standards and codes specify the fire rating of the assembly required to protect the openings.

X1.2.2 These fire protection standards and building codes permit labeled wire glass panels and other penetrations, such as labeled ventilation louvres, in some rated doors. The reader is referred to the model building codes, NFPA Standard No. 80, and the specific fire door manufacturer's label service for information on the types and sizes of these openings.

X1.2.3 Fire doors must also be properly installed to maintain their fire rating. Again, NFPA Standard No. 80 and the specific fire door manufacturer's label service should be consulted for details on the installation of fire door assemblies and for limitations on the application of specific labeled fire doors.

X1.3 Historical Aspects

X1.3.1 The first effort to test fire doors is reported in a series of tests conducted in Germany in 1893 (**13, 14, 15**). The British Fire Prevention Committee began testing in 1899 and produced a Standard Table of Fire Resisting Elements including Fire Resisting Doors (**1**). Underwriters Laboratories Inc. was involved in testing and listing fire doors shortly after 1900 using their own standards. ASTM adopted Methods E 152 on fire door assembly tests in 1941.

X1.4 Scope and Significance

X1.4.1 Methods E 152 are intended to provide methods for measuring the relative performance of fire door assemblies when exposed to predetermined standard fire conditions. The standard provides for testing of several classifications, types, and methods of door operation including swinging, sliding, rolling, and sectional doors (**6**). Since the effectiveness of the opening protection is dependent upon the entire assembly, proper attention must be paid to the installation as a unit. Accordingly, fire door assemblies are required to be tested as an assembly of all necessary elements and equipment, including the door frame and hardware.

X1.4.2 Fire protection ratings are assigned to indicate that the assembly has continued to perform as required for periods of 3, 1½, 1, ¾, ½ or ⅓ h. Labels on assemblies also carry the lettered designations of A, B, C, D, or E. These letter designations are not a part

[2] The boldface numbers in parentheses refer to the list of references at the end of this appendix.

of the E 152 standard classification system but are used to designate the class of opening for which the door is designed as determined by other standards (**6, 11**).

X1.4.3 The ½-h, or 20-min fire-rated door is relatively new. Concern about the uniform adequacy of the 1¾ in. (44.5-mm) solid bonded wood core construction and the difficulty of determining equivalency of other types of doors, led to a voluntary consensus to test such doors for 20 min in the E 152 furnace using the same acceptance criteria as specified for door assemblies traditionally tested for a longer period of time except that the hose stream test is required by the test method but may not be required by regulatory codes.

X1.4.4 It is usual for fire door to have a fire protection rating lower than the wall in which it is installed, for example, a 1½-h fire door in a wall having a fire-resistance rating of 2 h. This is justified by the fact that under normal conditions of use the potential fire exposure in the vicinity of a door opening is lessened since there will be a clear space on both sides of the opening for traffic purposes. If the opening is not used, combustibles may be piled against the door, and the assumed enclosure protection will not be maintained. In these instances, the openings should be made equal to the rating of the wall or precautions taken to prevent storage of combustibles against the doors (**2, 6**).

X1.5 Limitations

X1.5.1 Methods intend that the door be tested until the conditions of acceptance are met for the desired exposure period unless the conditions of acceptance are exceeded in a shorter period. It is not intended that a fire door subjected to a building fire will be satisfactory for reuse after the fire.

X1.5.2 The variations in material performance preclude any prediction of an assembly's performance in walls other than those types used in the test. The standard also makes no provisions for measuring the generation of smoke and gases or other products of combustion from the unexposed side of the door. Temperature measurements on the unexposed side, when recorded, are stopped after 30 min.

X1.6 Furnace

X1.6.1 The methods provide details on the operating characteristics and temperature-measurement requirements of the test furnace. The walls of the furnace should be typically of furnace refractory materials and should be sufficiently rugged to maintain the overall integrity of the furnace during the fire-exposure period.

X1.6.2 The thermocouples in the furnace are located 6 in. (152 mm) from the face of the door or the wall in which the door is installed. Otherwise no furnace depth is specified. A depth of 8 to 18 in. (203 to 457 mm) has been considered desirable by most laboratories. The reader is urged to consult reference documents for a more comprehensive review of furnace design and performance (**16, 17**).

X1.7 Temperature – Time Curve

X1.7.1 A specific temperature – time relationship for the test fire is defined in the standard and in the Annex. The actual recorded temperature – time condition obtained in the furnace is required to be within specified percentages of those of the standard curve. The number and type of temperature-measuring devices are outlined in the standard. Specific standard practices for location and use of these temperature-measuring devices are also outlined in the standard.

X1.7.2 The standard temperature – time ($T - t$) curve used in E 152 is considered to represent a severe building fire (**3**). The curve was adopted in 1918 as a result of several conferences by eleven technical organizations, including testing laboratories, insurance underwriters, fire protection associations, and technical societies. It should be recognized that the $T - t$ relationship of these test methods represent only one real fire situation (**7, 8, 9, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27**).

X1.8 Furnace Control

X1.8.1 The standard contains specific instruction for measuring temperatures in the furnace and for selection of the required thermocouples. Thermocouples of the design specified are sufficiently rugged to retain accuracy throughout anticipated test periods. However, their massive construction results in a significant time delay in response to temperature change and results in temperatures exceeding the indicated temperatures during the early stages of the test period when the temperature rises rapidly. The iron or porcelain tubes surrounding the junction and leads of the thermocouple provide a shield against degradation of the junction and increase the thermal inertia. It is customary for laboratories to replace furnace thermocouples after three or four accumulated hours of use.

X1.9 Unexposed Surface Temperature

X1.9.1 Conditions of acceptance for fire-resistive walls specify that the temperature increase on the unexposed side of the wall not exceed an average of 250°F (139°C) above ambient, and that there be no passage of flames or gases hot enough to ignite combustibles. It is obvious that the necessity of maintaining some clearances for efficient operation of the door and the possibility of warping preclude completely any attempt to restrict escape of gases and minor flames on the periphery of doors.

X1.9.2 The standard describes a standard procedure for measuring the unexposed surface temperatures. However, unexposed surface temperatures are not a condition of acceptance for E 152. Building regulations do restrict temperature transmission for some wall-opening protectives (**6, 11**). For instance, it is usual for codes to limit the temperature rise on the unexposed side of fire doors protecting exit stairways to 450°F (250°C) during the first 30 min of test. This criterion assumes that a higher temperature would provide enough radiant heat to discourage if not prevent occupants from passing by the door during an emergency. It is present practice for testing laboratories to provide labels on fire doors indicating that the maximum transmitted temperature on the unexposed side is 250°F, 450°F, or 650°F (139°C, 250°C, or 361°C) above ambient. If not indicated on the label, the temperature rise during the first 30 min may or may not

be in excess of 650°F (361°C). Temperature rise on the unexposed side of glass panels and louvres is not measured.

X1.9.3 Information on the properties of pads used to cover the thermocouples on the unexposed surfaces may be found in Appendix A2 of ASTM Standard E 119.

X1.10 Test Assemblies

X1.10.1 Standard E 152 provides a relative measure of performance for door assemblies. In order to establish confidence that the tested doors will perform in a building as expected, the tested assembly and its installation in the test frame must be representative of actual use conditions. Therefore, the National Fire Protection Assn. Standard No. 80 (6) or such other standards or specifications should be consulted before testing an assembly.

X1.10.2 Methods E 152 provide additional minimum requirements including direction of door swing, location in relation to the exposed side of the wall, and specific clearance between the door and its frame or wall, or both. Regardless of other specifications, these instructions must be followed in order to make a comparative judgment on test results.

X1.11 Conduct of Tests

X1.11.1 The test frame or wall in which a door assembly is installed should be rugged enough to endure the exposed fire during the time period, without affecting the door assembly. Traditionally, this wall has been of masonry construction. Today, fire doors are installed in other than masonry walls and have been tested in walls framed with metal and wood studs covered with a number of materials.

X1.12 Furnace Pressures

X1.12.1 A fire in a building compartment will create both negative and positive pressures on door assemblies depending upon atmospheric conditions, height above ground, wind conditions, and ventilation of the compartment at the beginning and during the fire.

X1.12.2 Methods E 152 specify that the pressure in the furnace be maintained as nearly equal to atmospheric pressure as possible. Experience has shown this practice to be acceptable. The pressure in the furnace is required to be reported but the method of measuring it is optional with the laboratory.

X1.13 Hose Stream Test

X1.13.1 Immediately following a fire test, the test frame is removed from the furnace and the door assembly is subjected to the impact, erosion, and cooling effects of a stream of water from a 2½-in. (63.5-mm) hose discharging through a standard playpipe equipped with a 1⅛ in. (28.5 mm) tip under specified pressures (see 10.2). The application of water produces stresses in the assembly and provides a measure of its structural capability. Weights were once used to provide a measure of the ability of the assembly to withstand impact. The hose stream is considered to be an improvement in uniformity and accuracy over the weights.

X1.14 Conditions of Acceptance

X1.14.1 The standard provides a specific set of conditions by which the performance of the door is measured, the most important being that it remain in place during both the fire test and the hose stream test. Instructions for conducting the hose stream test are detailed in the standard.

X1.15 Additional Information

X1.15.1 Inquiries concerning Methods E 152 should be addressed to ASTM Subcommittee E05.12.

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APPENDIX B

UNDERWRITERS LABORATORIES, INC., REPORT ON TESTING FIRE DOORS WITH HOSE PORTS

cc: File USNC142
NFF - USCG (3)
NFF - H. J. Gruszynski
NFF - Sec. D Aide

UNDERWRITERS LABORATORIES INC.

REPORT

on

FIRE TESTS CONDUCTED UNDER PURCHASE ORDER
NOS. DTCG50-86-P-01554
AND DTCG50-86-P-01650

by

Howard J. Gruszynski

for

United States Department of Transportation
United States Coast Guard
Research and Development Center
Groton, CT

Representative: Mr. David E. Beene, Jr.
Fire Safety Specialist

November 3, 1986

File USNC142
Project 86NK24389

N O T I C E

A B S T R A C T

Two fire tests were conducted with each assembly consisting of two Class A-15 marine type fire doors installed in Class A-60 bulkhead assemblies. Three of the doors were provided with a hose port. Three of the doors were installed so as to swing into the furnace chamber and one to swing away. The bulkhead assemblies were constructed using 11 USSG steel plate protected with USGG approved structural insulation as specified in the USCG "Guide To Structural Fire Protection Aboard Merchant Vessels."

Each fire test was conducted for a 1 h duration essentially in accordance with the ASTM E152 Standard for Fire Tests of Door Assemblies. After the 1 h fire endurance test each test panel was immediately removed from the furnace and the door assemblies subjected to the hose stream test specified in ASTM E152.

During each test observations and measurements were made of the passage of flame and water through the door assemblies, the temperatures on the unexposed and exposed faces of the door assemblies, temperature within the furnace chamber, heat flux incident on the exposed face of the test frame, relative pressure within the furnace, movement of the doors and hose port and ignition of cotton wool placed over critical areas on the unexposed side of the door assemblies, with particular reference to the hose port area of the doors. Photographic and video records of the tests were obtained.

F O R E W O R D

This is a final report of an investigation conducted under Purchase Order Nos. DTCG50-86-P-01554 and DTCG50-86-P-01650 issued by the United States Department of Transportation, United States Coast Guard for the second phase of their R & D Project No. 2284.

The test work was conducted on October 7, 1986 (Purchase Order No. DTCG50-86-P-01554) and October 8, 1986 (Purchase Order DTCG50-86-P-01650).

Respectfully submitted

UNDERWRITERS LABORATORIES INC.

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Reviewed and approved by:

K. W. HOWELL
Associate Managing Engineer
Fire Protection Department

I N D E X

I N T R O D U C T I O N

This investigation was initiated to provide test data to United States Coast Guard (USCG) concerning the performance under a standard fire exposure test of marine type fire doors employing hose ports.

The object of this investigation was to develop data on the fire performance of the door and frame assemblies by means of fire exposure and hose stream tests conducted in accordance with the Standard, "Fire Tests of Door Assemblies", ASTM E152. The tests were conducted in accordance with ASTM E152 except as follows:

1. The pressure inside the furnace was controlled such that the neutral pressure plane was located at the top edge of the hose ports.

2. Additional thermocouples were placed in the furnace to record temperatures on the exposed face of the door and in the furnace chamber at specified locations at the request of the USCG.

3. One of the door assemblies was installed so that it was away from the furnace.

4. Quick response type shielded furnace thermocouples were used to record furnace temperatures, rather than the slower response type protected thermocouples specified in the ASTM E152 Standard.

5. Thermocouple pads used on the unexposed face of the assembly were of the type specified in the "Test Specifications for Bulkhead Panels, 46CFR, Subpart 164.008.

6. Flame penetration on the unexposed face of the door assembly was determined by means of cotton wool pads placed over critical areas as described in Subpart 164.008.

7. Heat flux readings and additional temperature measurements on the exposed and unexposed faces of the assemblies were made at the request of the "USCG".

CONSTRUCTION DETAILS:

GENERAL

Each test door assembly consisted of a hollow-metal door, pressed steel frame, 3 mortise hinges, and a mortise lock, received as an assembled unit from the manufacturer. Three of the doors were fitted with hose ports of various designs located at the bottom latch edge corner of each door. The door assemblies were reported as approved for Class A-15 locations.

See ILL. 1 for the test panel/bulkhead configuration.

DOORS

Each door was designed for an opening 36 in. (914 mm) in width and 70 in. (1778 mm) in height.

Each door consisted of steel faces spot welded to steel stiffeners. The doors were filled with mineral wood insulation.

HOSE PORTS

Three of the doors were constructed with hose ports. Each port was formed of steel and attached to the door with one hinge. The doors/ports were fixed with manual surface bolts, but they were altered so as not to cause accidental latching of the assemblies during the tests.

FRAMES

The frames consisted of sheet steel formed/welded into a four sided single rabetted frame. The frame throat was closed and brought out to a flange, which was welded to the face of the bulkhead panel. The closed spaces of the frames were filled with mineral wool. See ILL. 19 for details of the frame construction.

HARDWARE

Each assembly incorporated a UL Listed mortise type lockset with a 3/4 in. (19 mm) latch throw.

Each door was provided with 3 mortise type steel hinges 5 in. (127 mm) high. The hinges were attached to the door and frame with machine screws.

BULKHEAD

Each door and frame assembly was installed into a Class A-60 bulkhead. The bulkhead assemblies were mounted into a brick wall within the test panel.

See ILL. 16 for the construction of each steel bulkhead.

After the door assemblies were installed in the steel bulkheads, by continuously welding the frame flange to the bulkhead, USCG approved mineral wool structural insulation was applied on one side of the bulkhead assemblies. The insulation was attached by welding steel pins, on 12 in. centers, on the exposed face of the bulkhead. Structural insulation, 3 in. thick, was impaled on the pins, the insulation covered with a wire mesh, and then steel clips placed on the pins over the mesh to unitize the assembly. The interface between the bulkhead panel assemblies and the test panel was sealed to prevent leakage of hot gases along the edges of the test frame.

SAMPLE IDENTIFICATION

To aide in correlating the test results obtained during the two tests, all data is presented together and referenced by the following test sample designations:

Sample Designation	Sample Description
1N	North assembly of test No. 1 (door swinging in, double acting hose port).
1S	South assembly of test No. 1 (door swinging in, no hose port).
2N	North assembly of test No. 2 (door swinging in, hose port swing in).
2S	South assembly of test No. 2 (door swing out, hose port swinging out).

The general appearance of the exposed and unexposed faces of the test assembly No. 1 is shown by ILLS. 2 and 3, and of assembly No. 2 by ILLS. 9 and 10.

T E S T R E C O R D N O. 1

FIRE ENDURANCE TESTS

METHOD

After the brick wall of the test panels had seasoned, the fire tests were conducted in accordance with the Standard for Fire Tests of Door Assemblies, ASTM E152.

Throughout the fire tests, observations were made with respect to the character of the fire, the condition of the exposed and unexposed faces and all developments pertinent to the performance of the doors as a fire retardant with special reference to stability and flame passage.

RESULTS

Control of Furnace Temperatures and Pressure - Both fires were luminous and well distributed during the fire test. The temperatures within the furnace chamber were controlled in accordance with the Standard Time-Temperature Curve as shown on ILLS. 4 (test No. 1) and 11 (test No. 2) and defined in the ASTM E152 Standard. See ILL. 5 for the furnace thermocouple locations for both tests.

The pressure in the furnace chamber for each test was controlled so as to locate the neutral pressure plane at about the top edge of the hose ports. Measurements of the static pressure during the fire exposure tests were made using two pressure taps, one located at the top of the doors and one located at the top edge of the hose ports. The measurements recorded are shown in Appendix A for the correlated data. Appendicies C and D contain the data for Test Nos. 1 and 2, respectively.

Observations of Exposed Face of Test Assemblies - The observations on the exposed side were as follows:

Fire Exposure Time, min	Sample No.	Observations
4	1N, 1S	The doors were bowing towards the fire.
5	2N, 2S	The doors were bowing towards the fire.
10	2N, 2S	The paint has burned off the doors and frames. The bulkhead insulation has slightly discolored.
12	1N, 1S	The paint has burned off the doors and frames. The bulkhead insulation has slightly discolored.
30	1N, 1S, 2N, 2S	The hardware remained intact. The bowing of the doors slowed.
55	1N, 1S, 2N, 2S	No apparent change in the appearance during the last 30 minutes of fire exposure.

The general appearance of the exposed face after the 60 min fire exposure tests and before the application of the water stream is shown by ILLS. 6 (test No. 1) and 12 (Test No. 3).

Observations of Unexposed Side - The deflection of each door assembly was determined by measurements along the horizontal center line of the door at midheight. The measurement reference line was a fine, taut, steel wire spanning the width of the opening.

The deflections of each door and frame assembly toward the fire during the fire exposure were as indicated in Appendix A.

The unexposed surface temperatures of each door assembly were measured and recorded. The average unexposed surface temperatures were measured at 5 min intervals throughout the test. The recorded temperatures of the unexposed surfaces are shown in Appendix A. The thermocouple locations are shown in Ill. 5.

At the request of the USCG, the surface temperatures were measured under pads that were 2 by 2 in., rather than [illegible] in. Additionally, measurements were made at clearance openings between the door and frame and between the door and hose port as well as on the unexposed side of one bulkhead assembly. Radiometer and calorimeter readings were also taken during the tests. The locations of the flux measuring devices are shown on ILL. 17. The locations of the extra thermocouples are shown on the same illustrations as the door surface thermocouples. The comparative readings for all instrumentation are shown in Appendix A.

The observations on the unexposed face were as follows:

Fire Exposure Time, min	Sample No.	Observations
1	1N	Flames were visible looking through the gap around the hose port.
1	2N, 2S	Audible reports from the door. (The reports continued intermittently for the next 9 min.).
2	1N, 1S	Audible reports from the door. (The reports continued intermittently for the next 9 min.).
3	2N, 2S	The doors were bowing towards the fire.
3	1N	Smoke was coming out of the furnace between the frame and the door along the top and above the latch area.
3-1	1S	Smoke was coming out of the furnace between the top of the door and the frame.
4	2N, 2S	Smoke was coming out of the furnace between the top of the door and the frame.
4-1	1S	Loud audible report from the door.
6	1S, 1N	The doors are bowing towards the fire.
9	2N	A dry cotton pad was placed on the top of the door no change in the appearance of the pad.

-13-

Fire Exposure Time, min	Sample No.	Observations
10	2S	A dry cotton pad was placed near the top latch corner of the door - no change in appearance.
10	1S, 1N	A dry cotton pad was placed near the tops of both doors - no change in appearance.
11	1N	A dry cotton pad was placed near the hose port - the pad became slightly discolored.
11	2S, 2N	The bottom latch edge corners (hose ports) were bowed into the furnace.
11	2N	The top of the door was distorted. The latch area was beginning to discolor.
12-1/2	2S	Audible report from the door.
12-1/2	2S, 2N	Smoke/steam was coming from the latch area of both doors.
13-1/2	1N	Audible report from the door. The latch began loosing engagement because of the door's movement.
13-1/2	1S	The latch bolt had been bent over to the extent that there was almost no measurable engagement in its strike.
15	2S	A dry cotton pad was placed near the top latch edge corner - no change in the pad.
19	2S	Audible report from the door.
2[illegible]	1S, 1N	The door faces were rapidly discoloring.
25	1S, 1N	Dry cotton pads were placed near the top of each door - there was no change in the pads.

Fire Exposure Time, min	Sample No.	Observations
26	1N	A dry cotton pad was placed near the hose port - the pad had some moisture deposited on it.
30	1N	The latch was loosing more engagement.
32	1N	Loud report from the door.
35	1N	The north door was discoloring more rapidly than the south door in Test No. 1.
35	2S	A dry cotton pad was placed near the top latch corner of the door - there was no change in the pad.
36	2N	A dry cotton pad was placed near the top center of the door - the pad became heavily discolored.
40	1S,1N	Intermittent flicks of flame came from the furnace, between the frame and the edge of the door, in the area above the latch.
40	1S, 1N	Dry cotton pads were placed near the areas where flames were observed - the pads became charred.
40	2N	The frame was distorting/bowing in the area of the center hinge.
40	2S	The top hinge corner of the door began bowing away from the stop.
41	1N	The charred paint was flaking off the door.
42	1N, 1S	Steam was issuing from the doors.
55	2S	Dry cotton pads were placed near the hose port and near the edge of the door above the latch - both pads slightly discolored.

Fire Exposure Time, min	Sample No.	Observations
55	2N	A dry cotton pad was placed near the edge of the door above the latch - the surface of the pad became heavily charred.
55	1S	A dry cotton pad was placed near the edge of the door above the latch - the surface of the pad became heavily charred.
55	1N	A dry cotton pad was placed near the edge of the door above the latch. While the pad was in position a flame flicked from the joint between the door and the frame and ignited the pad.
60-1/2	1S, 1N	After the last reading of the unexposed instrumentation, the furnace was turned off and the samples subjected to the hose stream test.
60-1/2	2S, 2N	After the last reading of the unexposed instrumentation, the furnace was turned off and the samples subjected to the hose stream test. Prior to shutting the furnace off, an attempt was made to place a cotton pad in front of an opened hose port. The attempt was aborted when the 2S door hose port could not be forced open because of the assembly's distortion during the test.

HOSE STREAM TESTS:

METHOD

Immediately after the 60 min fire exposures, the assemblies were withdrawn from the furnace and subjected to the impact and cooling effects of the 30 psi (207 kPa) hose stream for 18 s, per door/frame assembly, as specified in the Test Standard for a 60 min fire exposure.

RESULTS

During the application of the hose stream the door bowed out and normal amounts of water passed between the frame and the door.

The hardware held the door closed in accordance with the conditions of acceptance for an exposure period of 1 h. The latch bolts on the 1S and 2N doors were completely bent over and were not engaged in their strikes. The latch bolt on the 1N door increased its engagement from that of the fire test. The latch bolt of the 2S door remained projected and was intact after the test. The hardware was not operable after test.

The test assemblies withstood the hose stream test without developing openings anywhere through the assembly.

The door assemblies remained in their opening during the hose stream test.

The movement of the four swinging doors resulted in the latch edge on door 1S to move from its original position in a direction perpendicular to the plane of the door a maximum of 1-1/4 in. (31.8 mm) above the latch location as a result of the hose stream test.

The door frames remained securely fastened to the bulkheads on all sides and did not permit through openings between frame and door, or between frame and bulkhead.

The appearance of the exposed and unexposed faces after the fire and hose stream exposure tests for Test No. 1 is shown on ILLS. 7 and for Test No. 2 by ILLS. 13 and 14.

S U M M A R Y

FIRE RETARDANT PROPERTIES:

There was no flaming on the unexposed surface of a door assemblies 2S and 2N during the fire exposure period.

After 30 min, some intermittent light flames (not exceeding 6 in. (152 mm) long), for periods not exceeding 5 min intervals, did occur along the edges of 1S and 1N doors.

The hardware held the doors closed in accordance with the conditions of acceptance for the entire fire exposure period. The latch bolt on the doors 1N, 2S and 2N only, remained engaged in their strikes and were intact after the test.

The test assemblies withstood the fire endurance test, without developing openings anywhere through the assembly.

The door assemblies remained in the opening during the fire endurance tests.

The movement of the swinging doors did not result in any portion of the edges to move from their original position more than the thickness of the door during the entire fire exposure period.

The three inswinging doors separated more than 1/2 inch (12.7 mm) at the latch location.

The door frames remained securely fastened to the bulkheads on all sides and no through openings developed between the frame and door, or between the frame and bulkhead.

HOSE STREAM RESISTANCE:

The hardware held the door closed in accordance with the conditions of acceptance for the entire hose stream exposure period. The latch bolt on doors 1N and 2S, only, remained engaged in their strikes and were intact after the test.

Each test assembly withstood the hose stream test, without developing openings anywhere through the assembly.

Every door assembly remained in the opening during the hose-stream test.

The three inswinging doors continued to be more than 1/2 inch (12.7 mm) from their original position at the latch location.

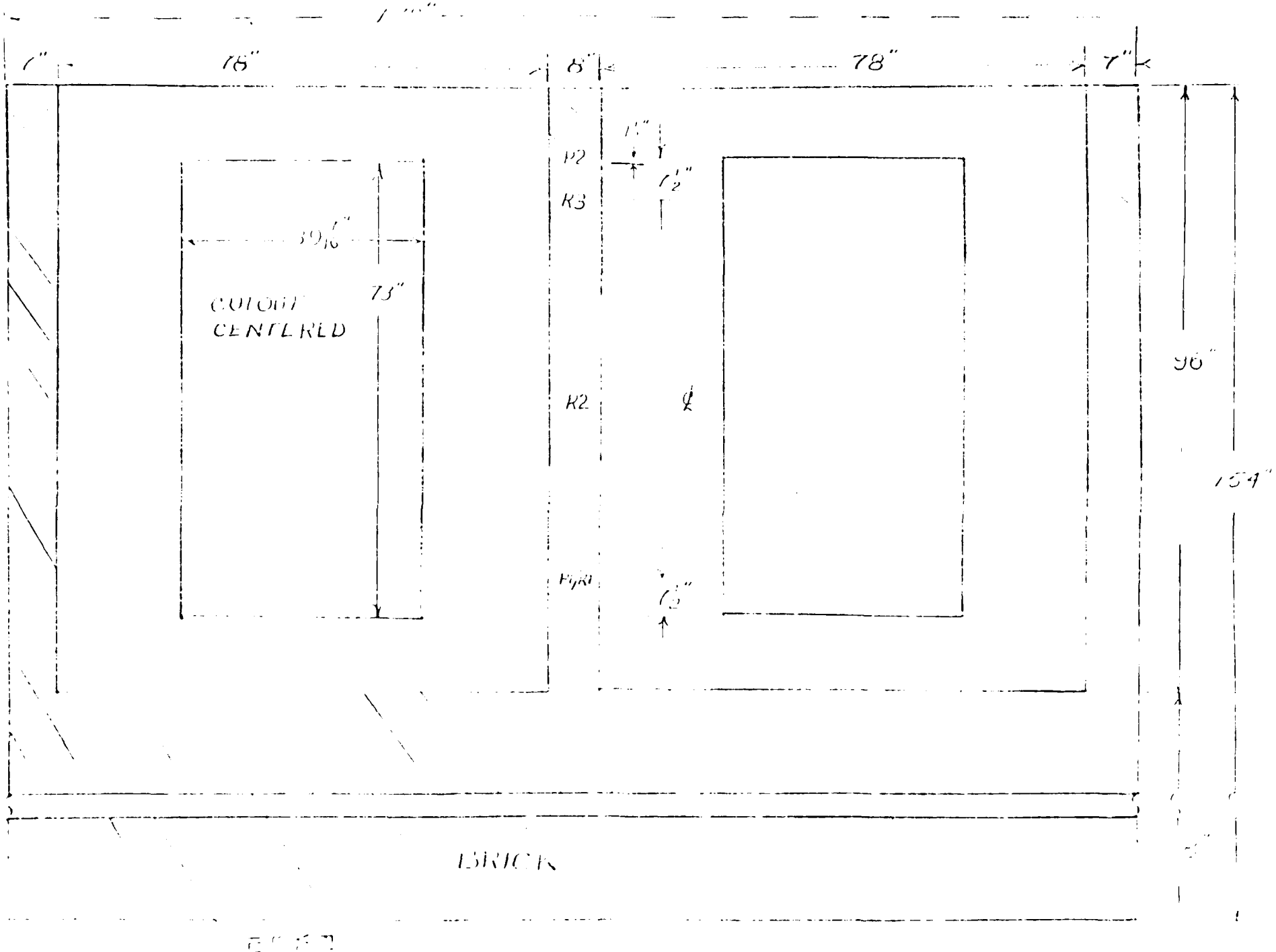
The movement of the swinging doors did not result in any portion of the edges adjacent to the door frame moving from their original position in a direction perpendicular to the plane of the door more than 2-7/8 in. (73.0 mm) during the hose stream test.

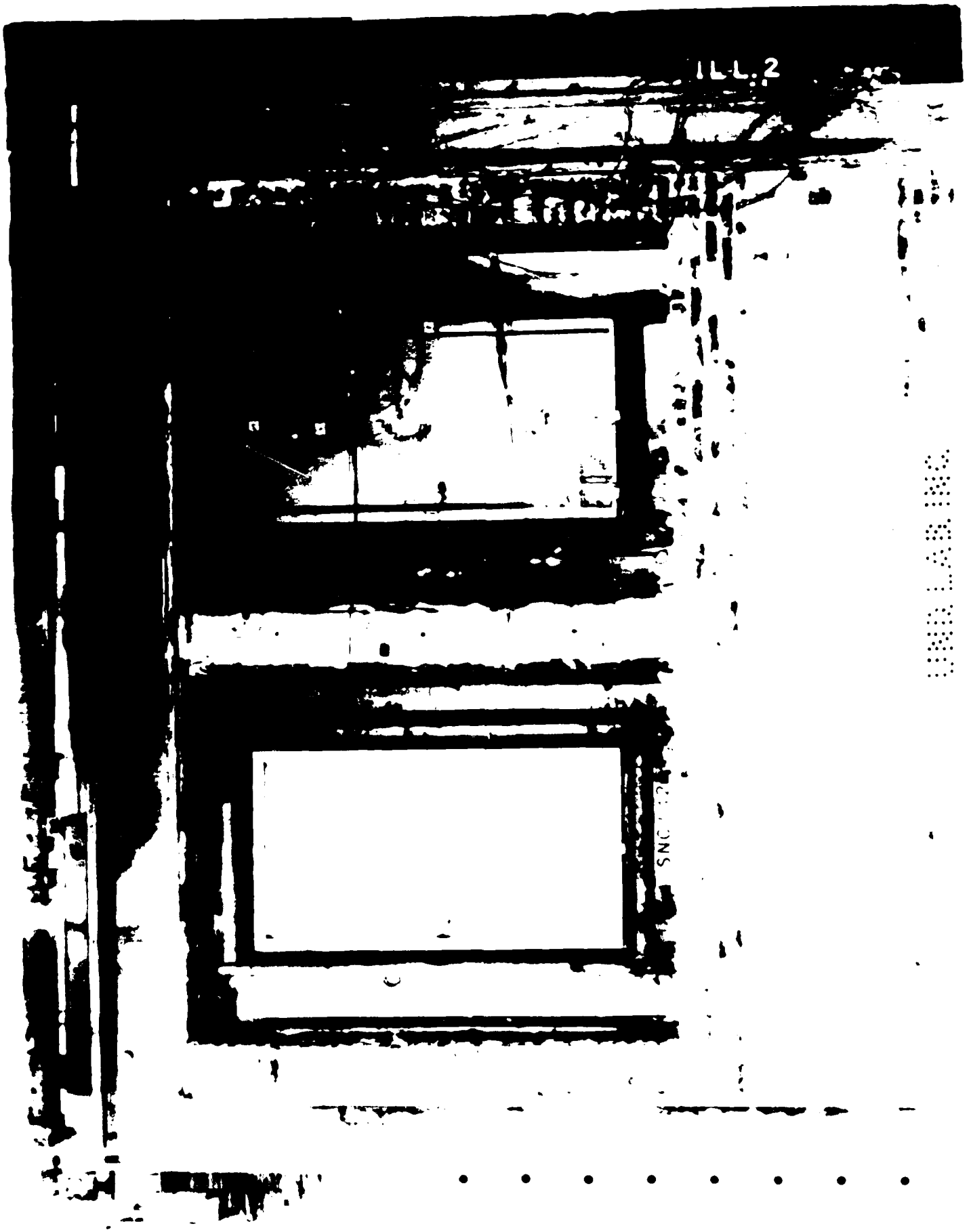
Each door frame remained securely fastened to the bulkhead on all sides and did not permit through openings between the frame and door, or between the frame and bulkhead.

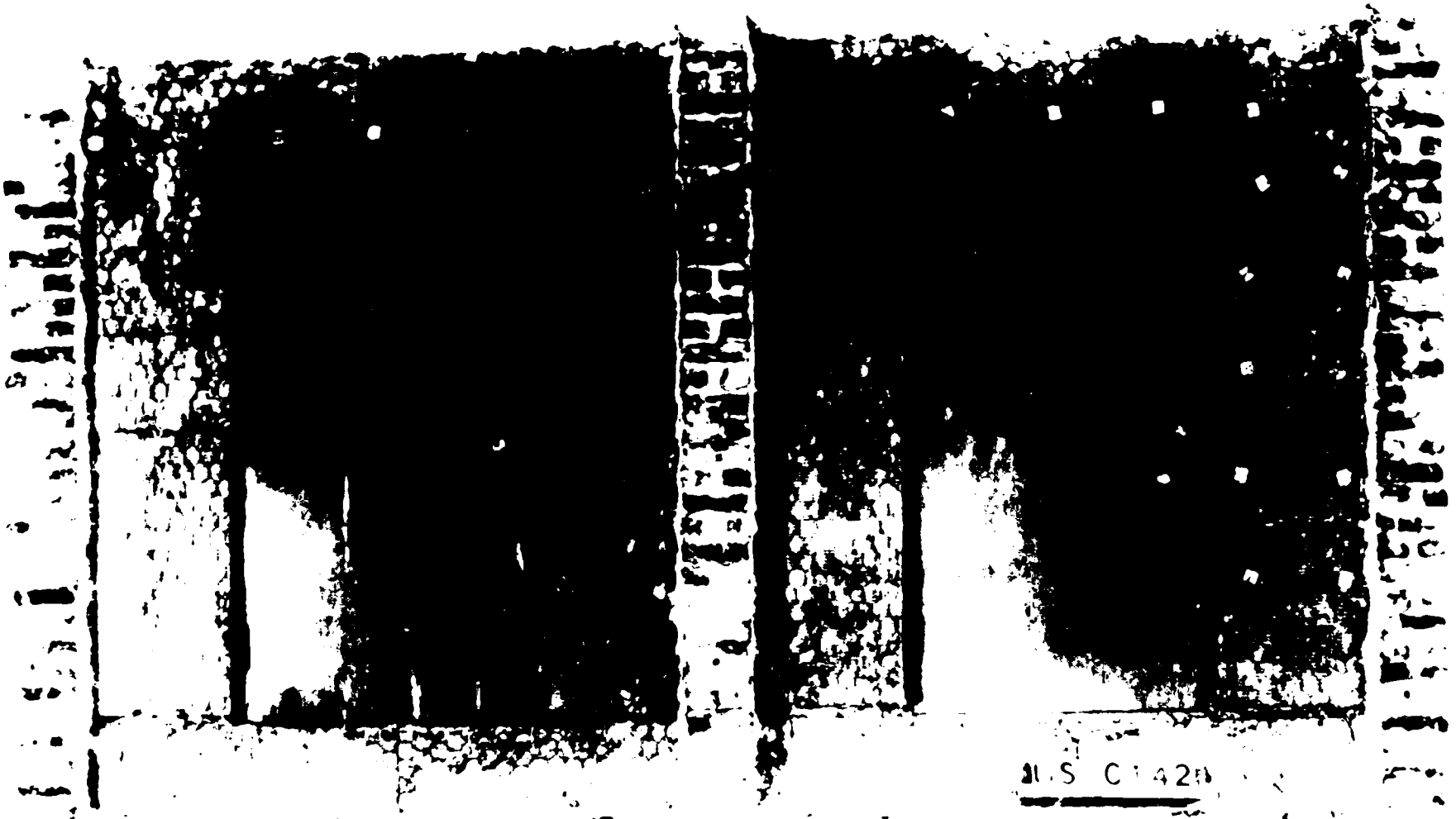
HJG/KWH:sb
LET1

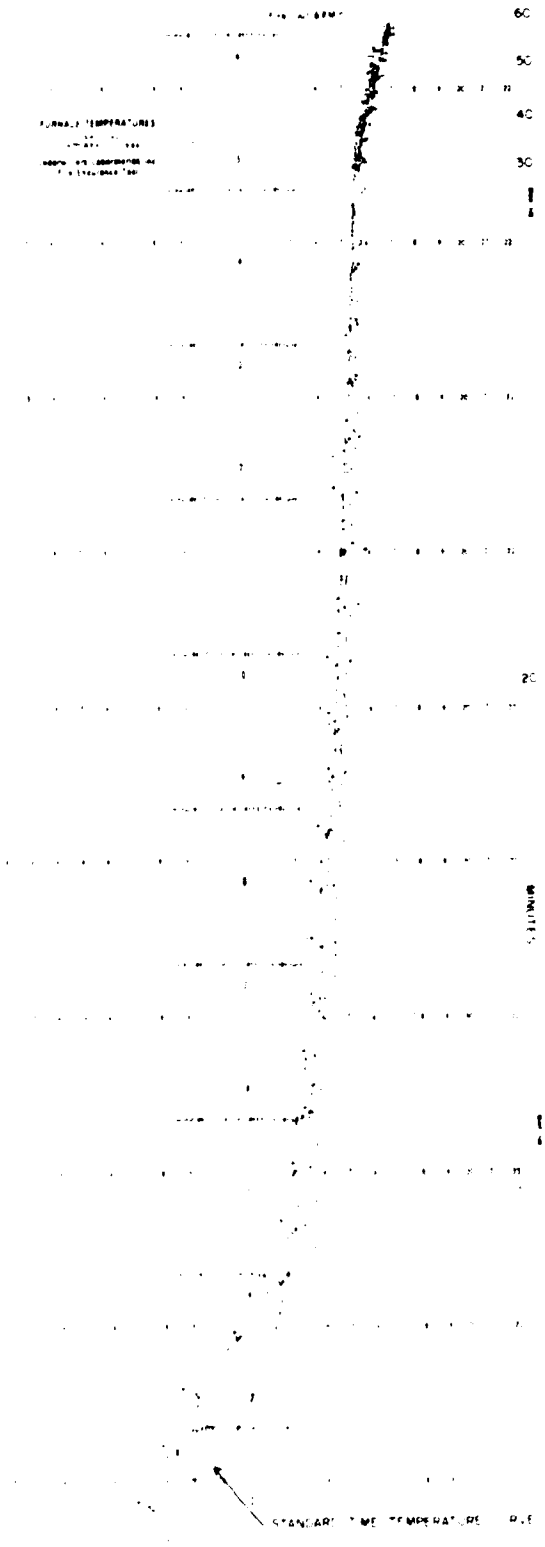
DESCRIPTION OF ILLUSTRATIONS

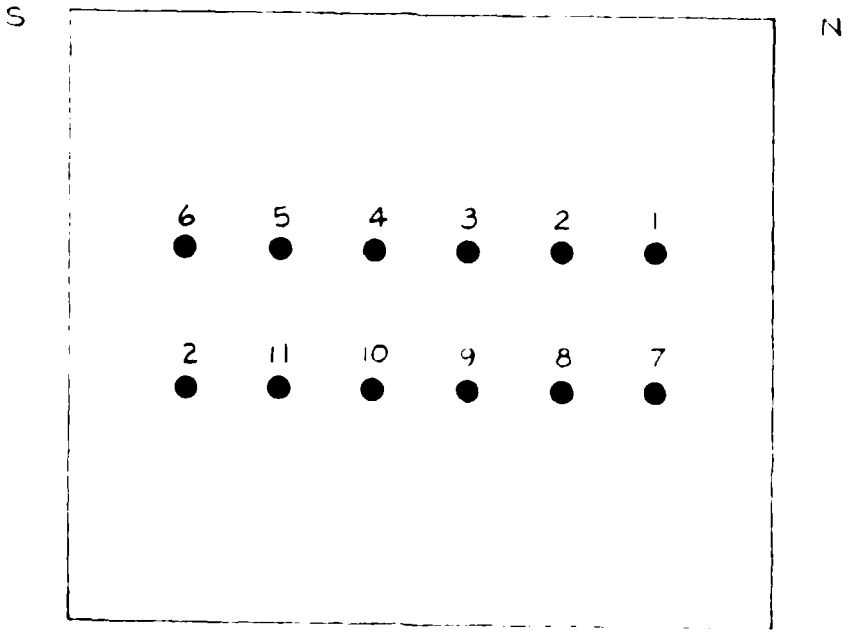
ILLUSTRATIONS Test Samples 1N and 1S	ILLUSTRATIONS Test Samples 2N and 2S	DESCRIPTION
1	1	Test Panel Construction
2	9	Unexposed side of the test assembly prior to test.
3	10	Exposed side of the test assembly prior to test
4	11	Furnace temperatures used to control test.
5	5	Furnace thermocouple locations.
6	12	Exposed side of the assembly after fire exposure and before the hose stream.
7	13	Unexposed side of the test assembly after the fire and hose stream test.
8	14	Exposed side of the test assembly after the fire and hose stream test.
15	15	Locations of requested extra furnace thermocouple locations.
16	16	Bulkhead Construction.
17	17	Locations of requested thermocouples and measurement points on test door frame assembly, and locations of requested supplemental instrumentation (radiometers, calorimeters, pressure taps).
18, 19	18, 19	Door assembly constructions as described by the manufacturer.


7"
78"
8"
78"
7"
1"
P2
K3
1½"
39 1/16"
73"
CUTOUT
CENTERED
96"
K2
154"
P3R1
1½"
BRICK


ILL.2



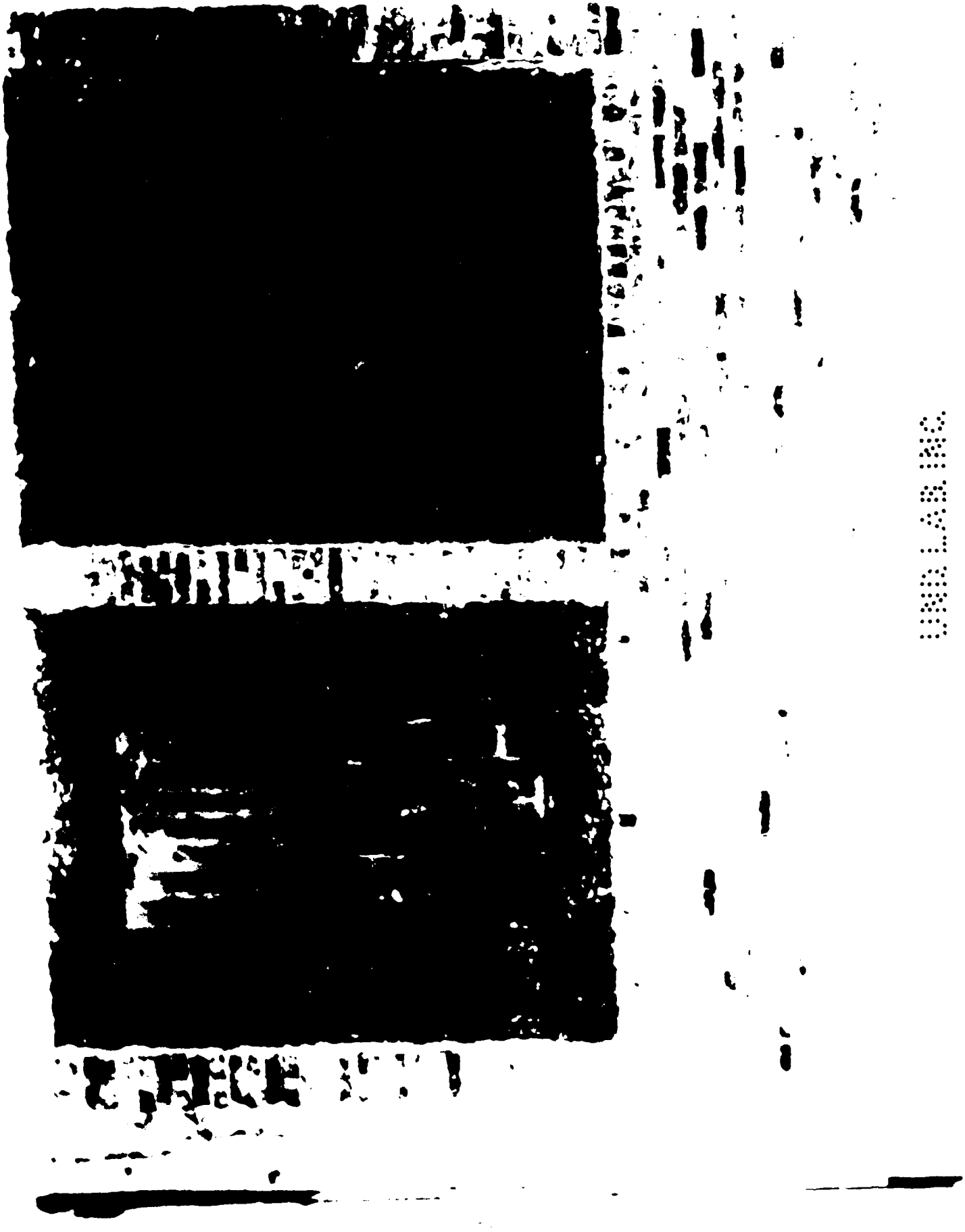

60
50
40
30
20
MINUTES

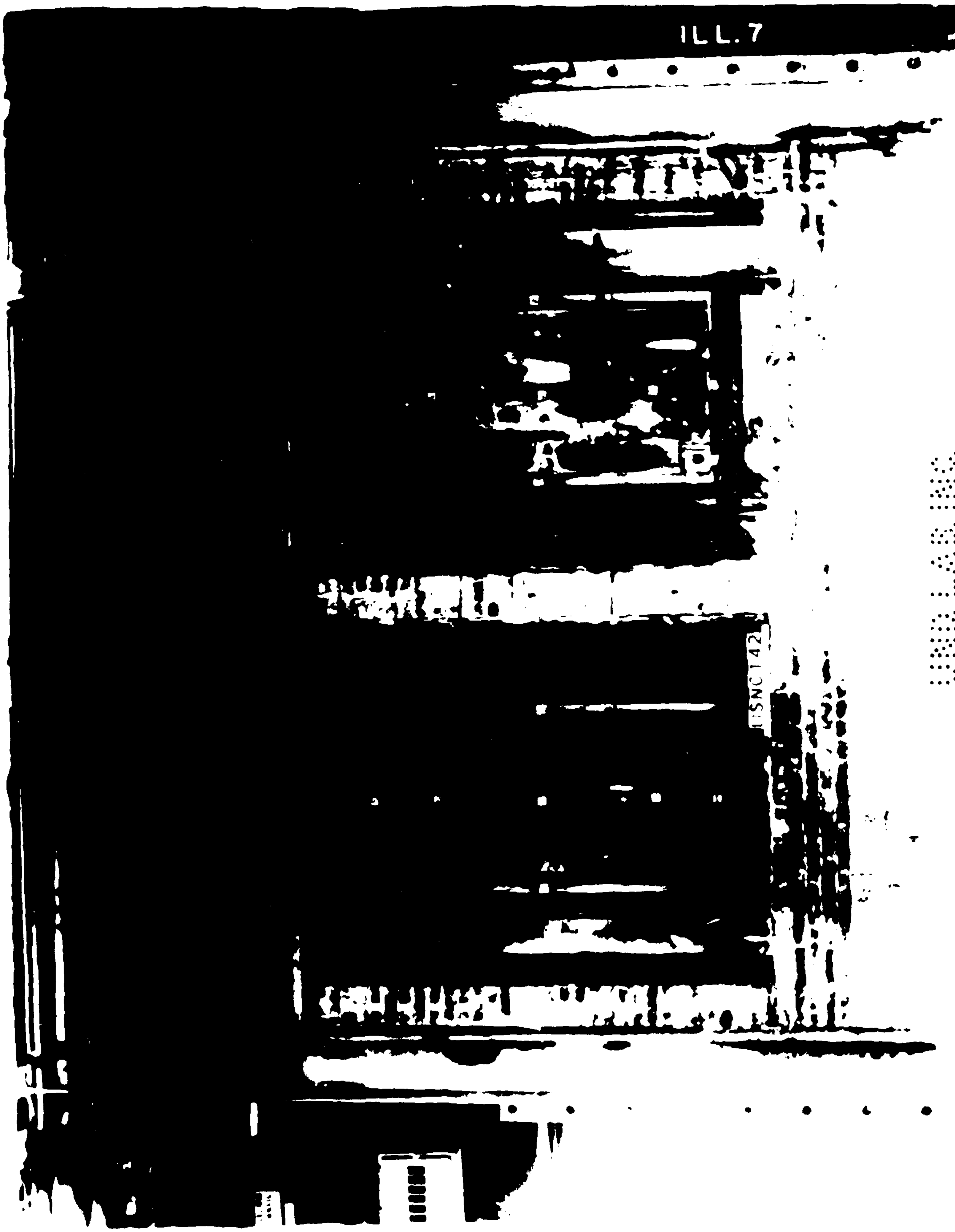


● - THERMOCOUPLE LOC'NS
FOR FURNACE CONTROL

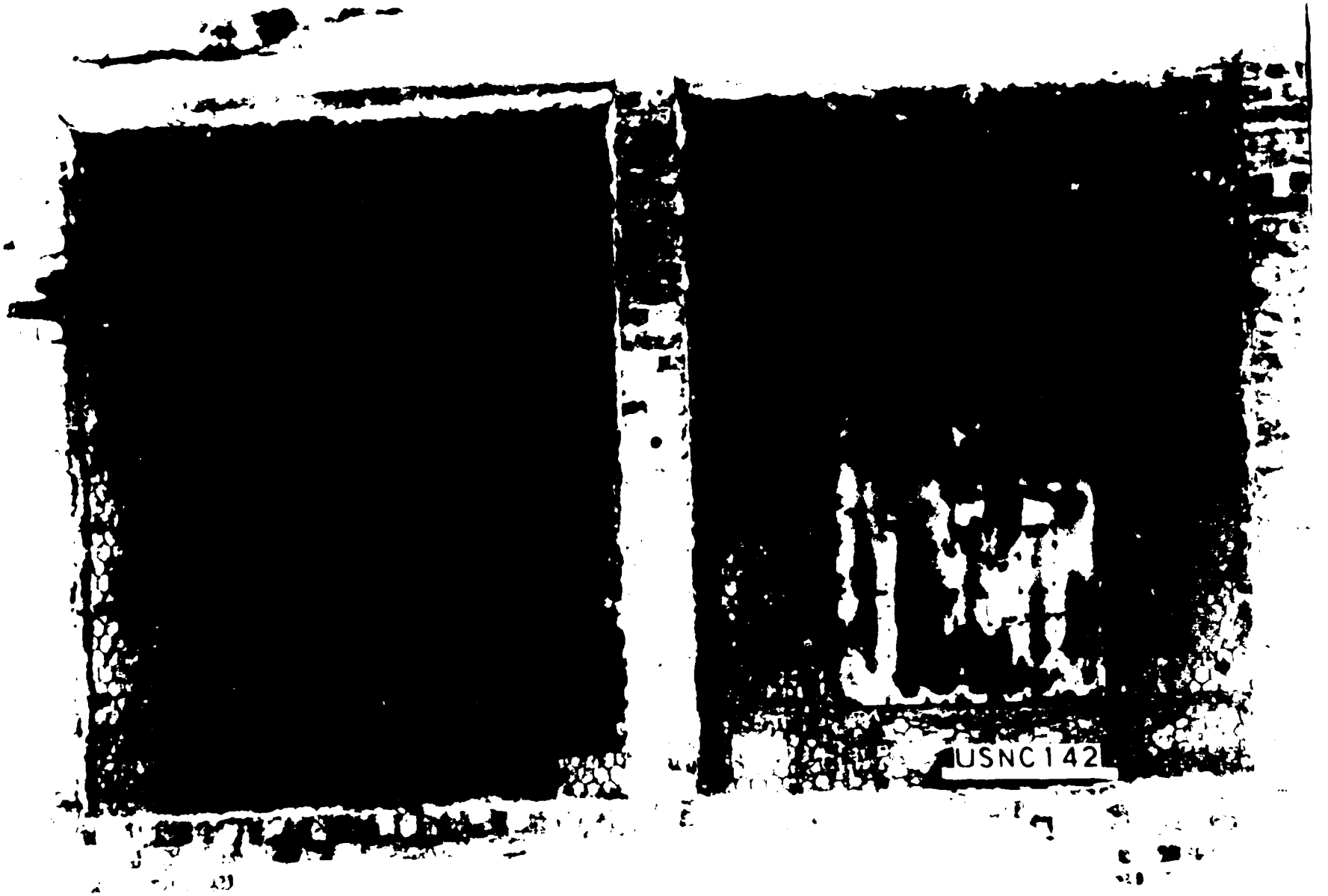
USNC 142

11-3-86



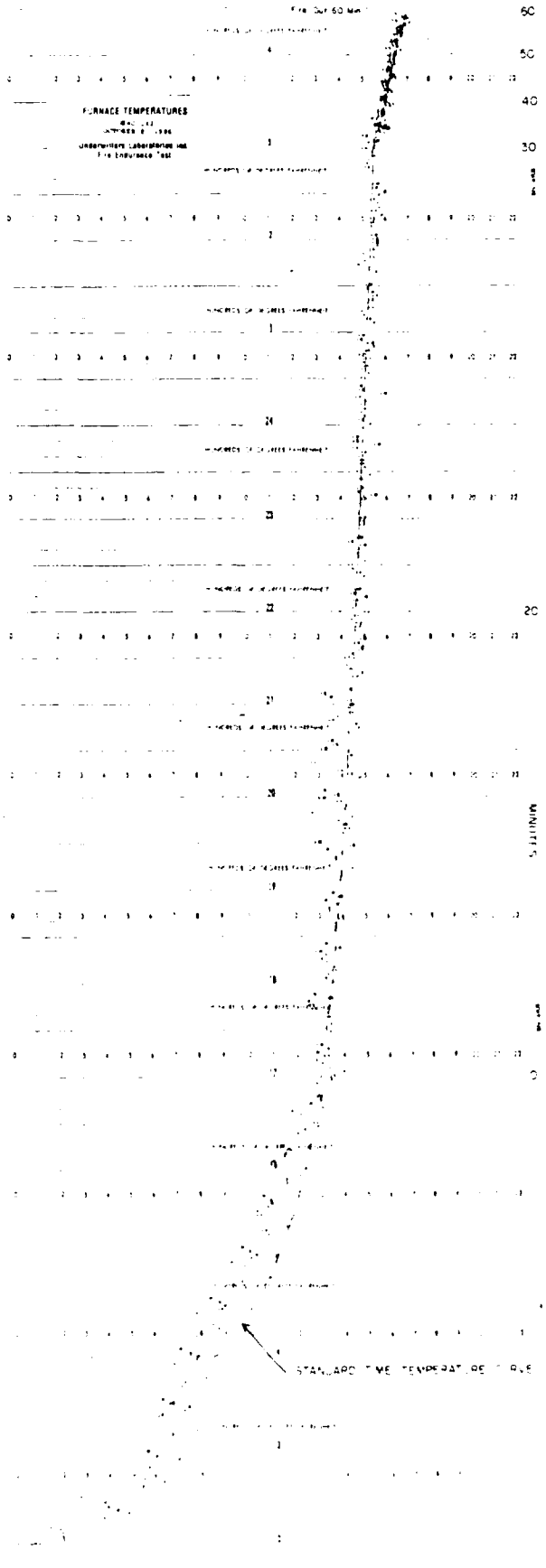


ILL. 7



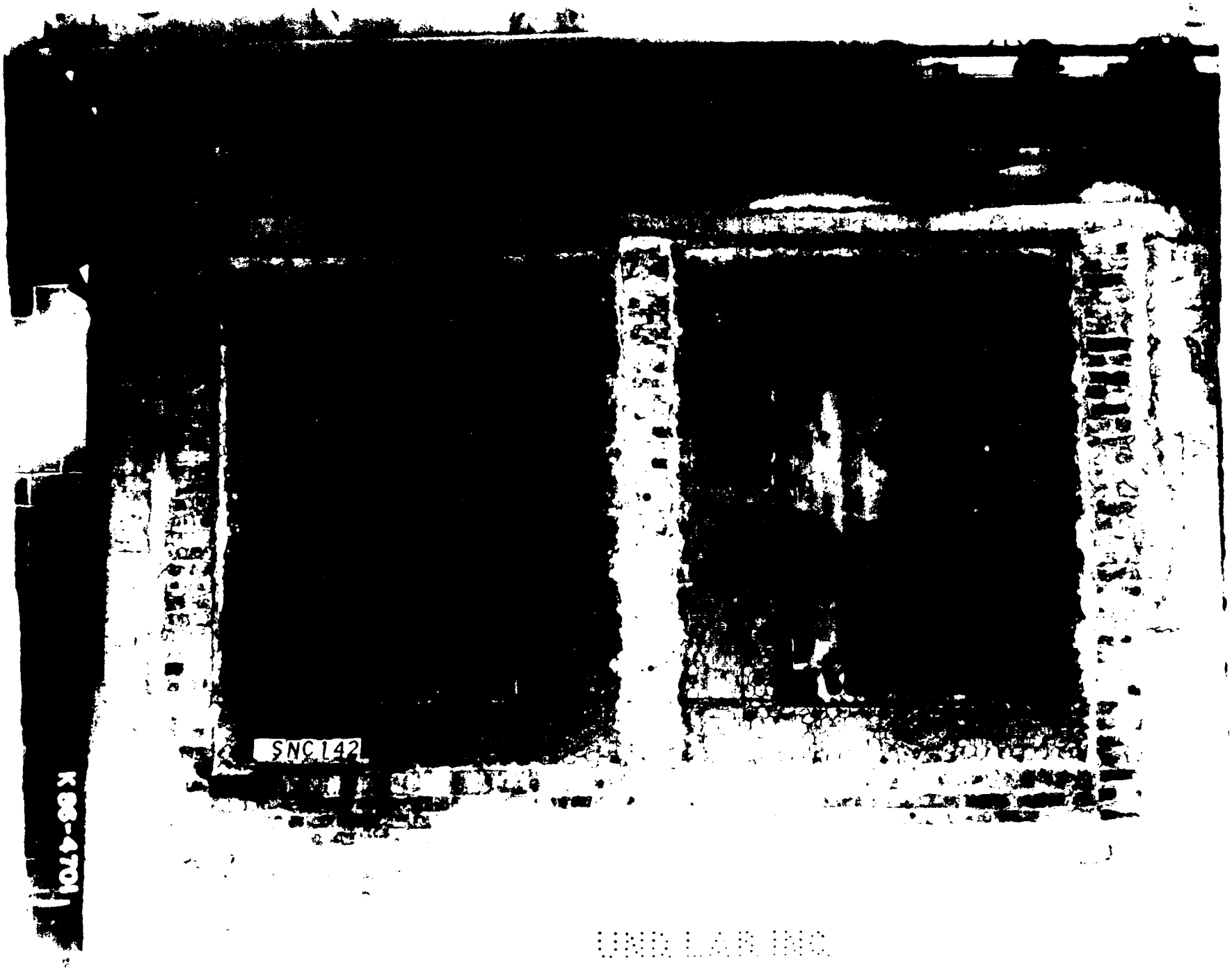

UNO LAB INC

UNDERLAB INC.


FURNACE TEMPERATURES
60
50
40
30
20
MINUTES
0


K86-4705


ILL.13
USNC 42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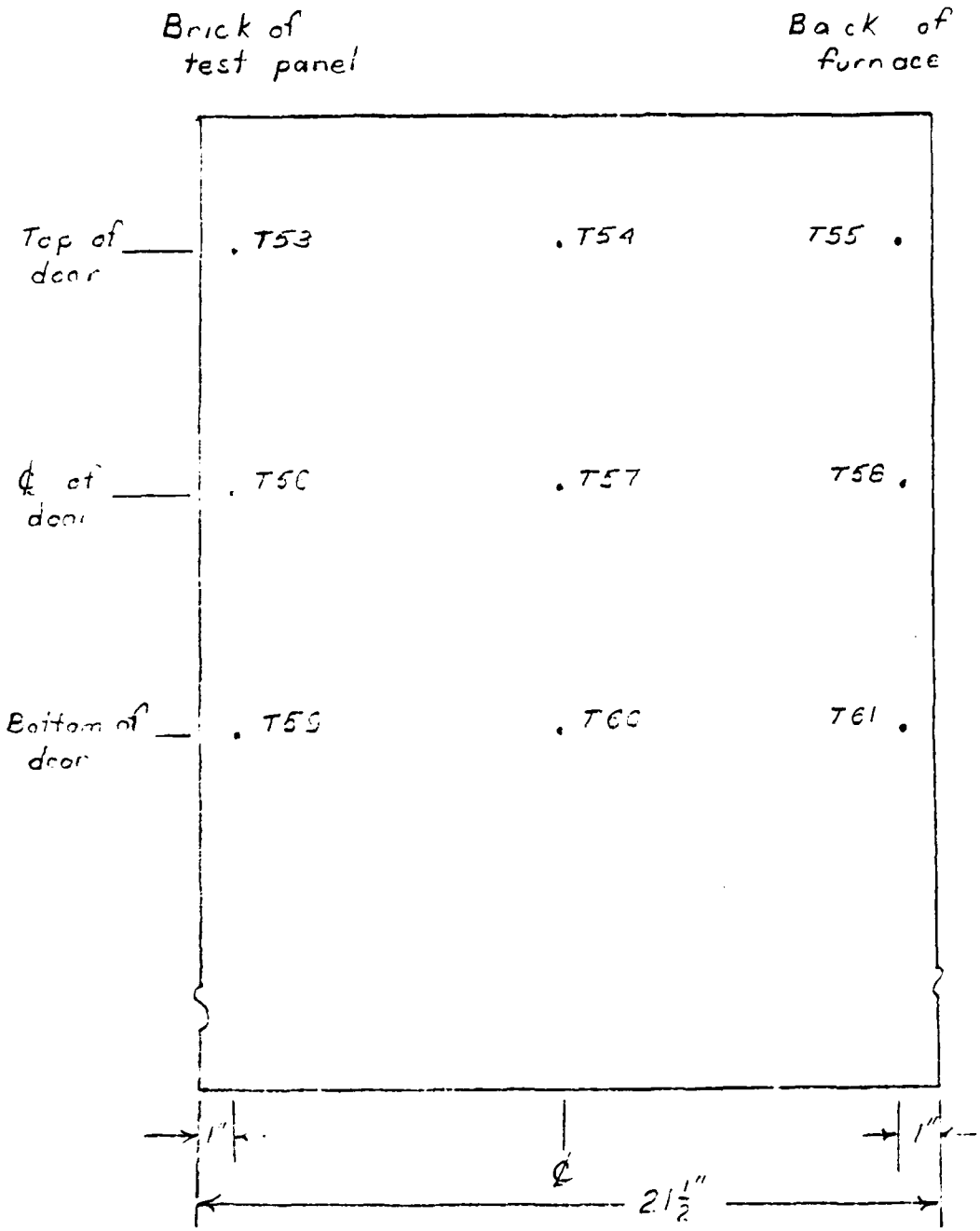
K83-4701

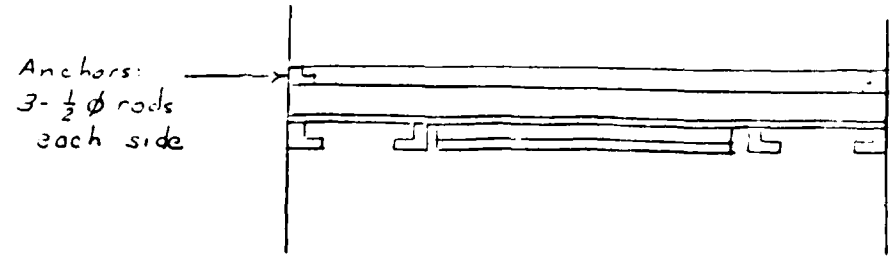


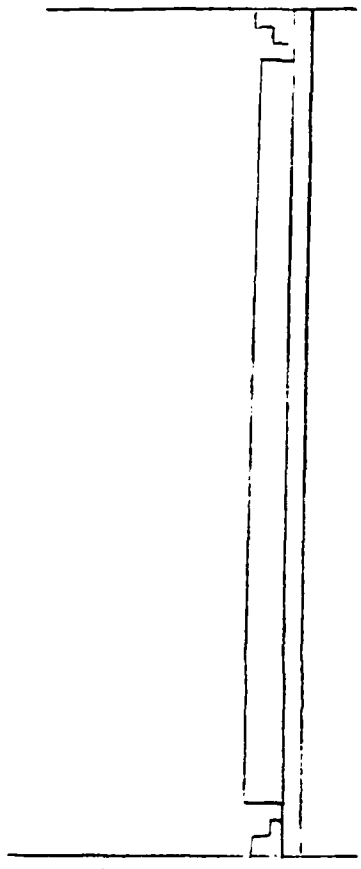
Front to back plane at ℄ of furnace

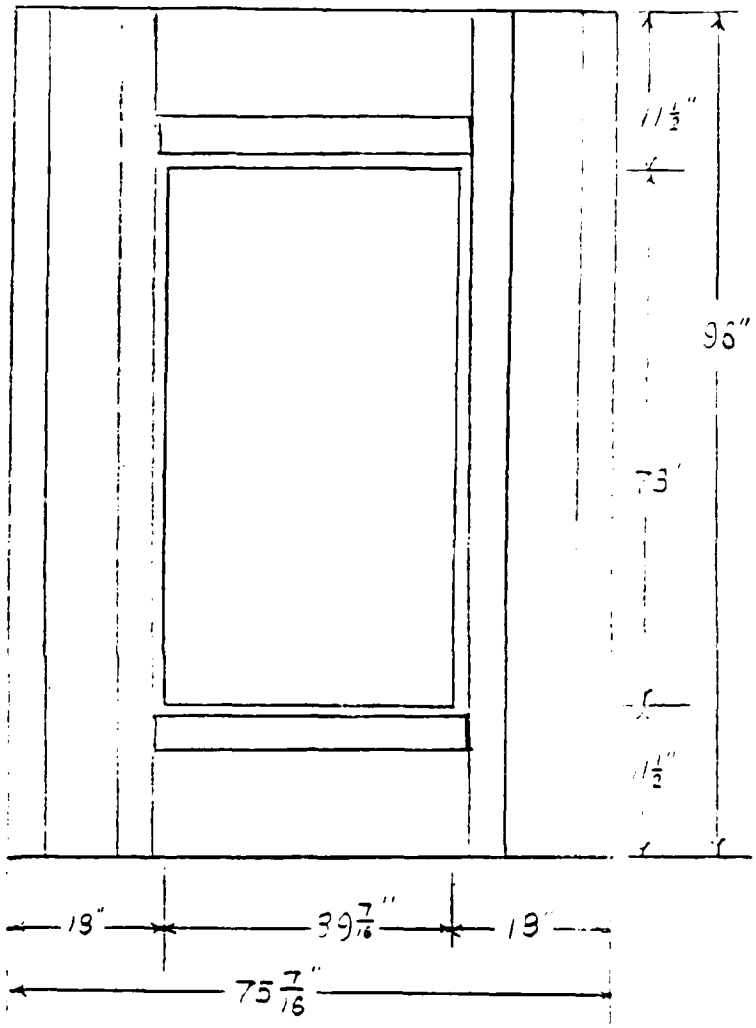
FURNACE THERMOCOUPLES
(SPECIAL GRID)

FILE USNC 142
VOL. —
SEC. —
ILL. 15
11-3-86

HJG: 11-3-86







UNEXPOSED SIDE

MATERIALS

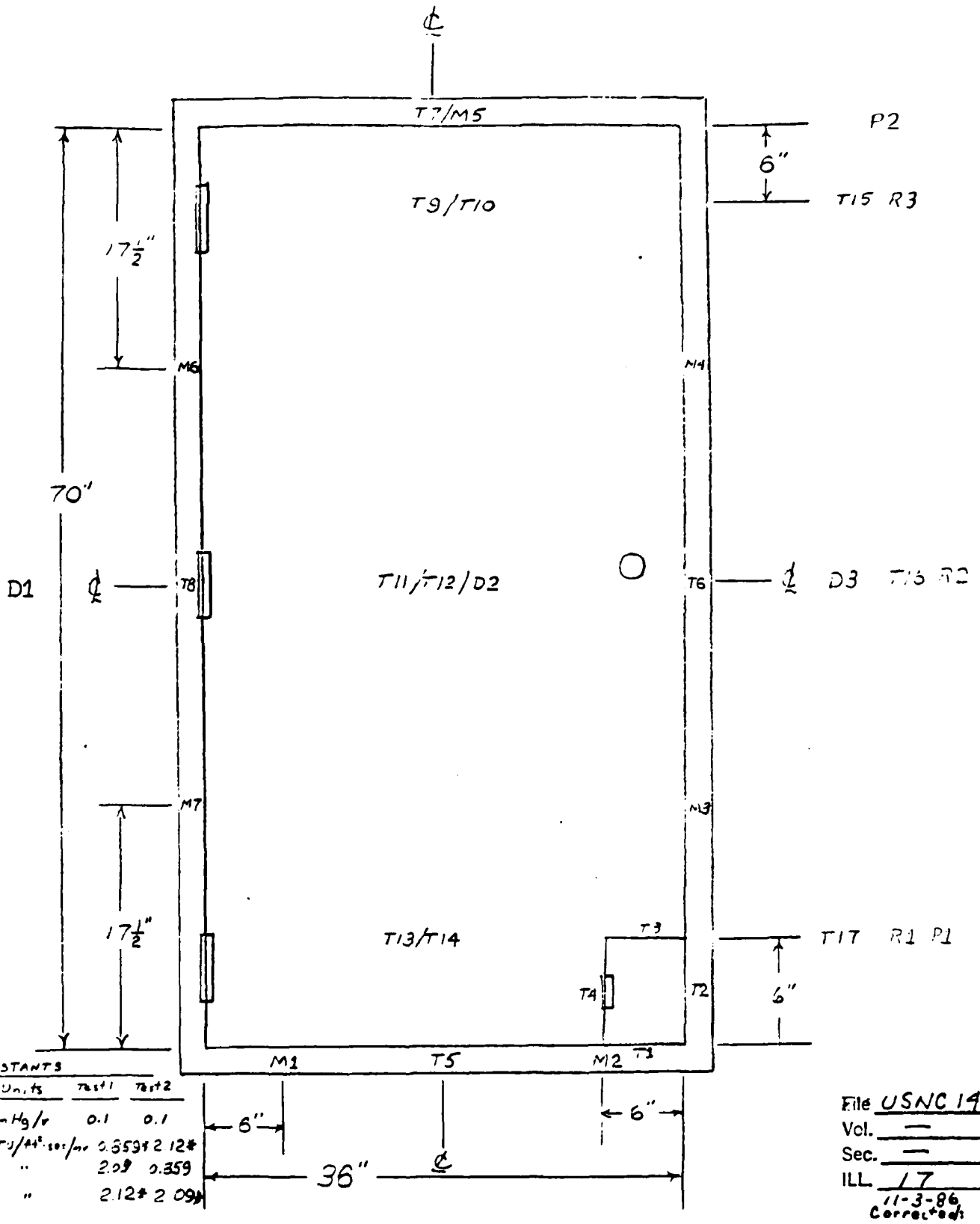
Bulkhead: 2 pc. - 18 × 96 × 11 Ga , 2 pc - 11½ × 39 7/16 × 11 Ga; Continuous weld

Reinforcements: 3 × 3 × 3/16 ; 2 pc @ 96 ; 2 pc @ 43 3/16 ; weld 1" on 12" centers

Mounting Angles: 2 × 2 × ⅛ ; 2 pc @ 75 7/16 ; 2 pc @ 91¾ ; weld 1" on 12" centers

HJG: 11-3-86

BULKHEAD CONSTPUCTION



CONSTANTS

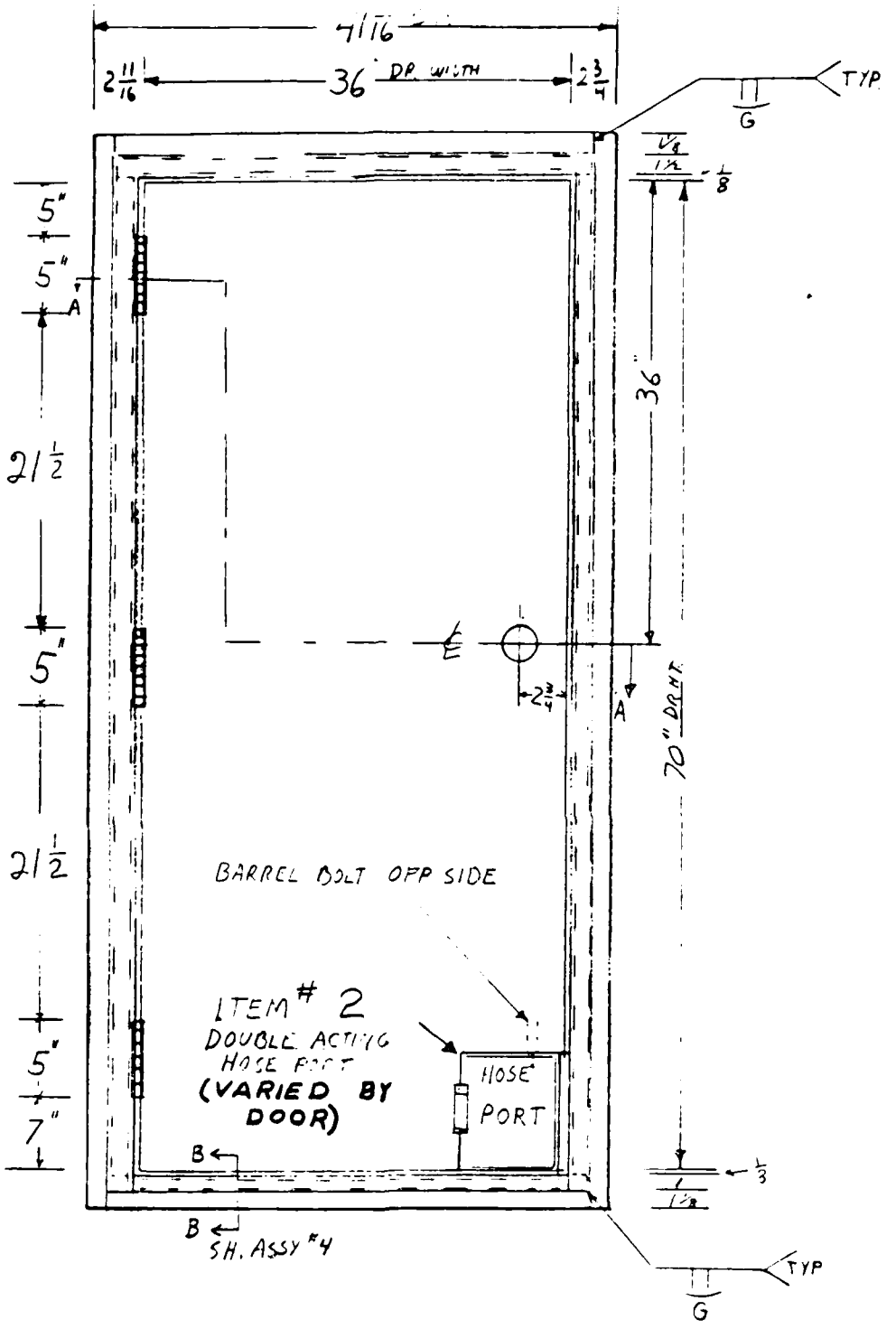
Device	Units	Test 1	Test 2
P1, P2	mm Hg/v	0.1	0.1
I	BTU/ft²-sec/mv	0.559	2.12
M2	"	2.09	0.359
D3	"	2.12	2.09

File USNC 142
Vol. —
Sec. —
ILL. 17
11-3-86
Corrected
1-29-87

INSTRUMENTATION / MEASUREMENTS

LEGEND: T = Thermocouple R = Flux reading P = Pressure top
M = Measurement location D = Deflection location;
T10, T12, T14 are on exposed face; D1, D3, T15, T16, T17 are
on bulkhead; P1, P2, R1, R2, R3 are between bulkheads

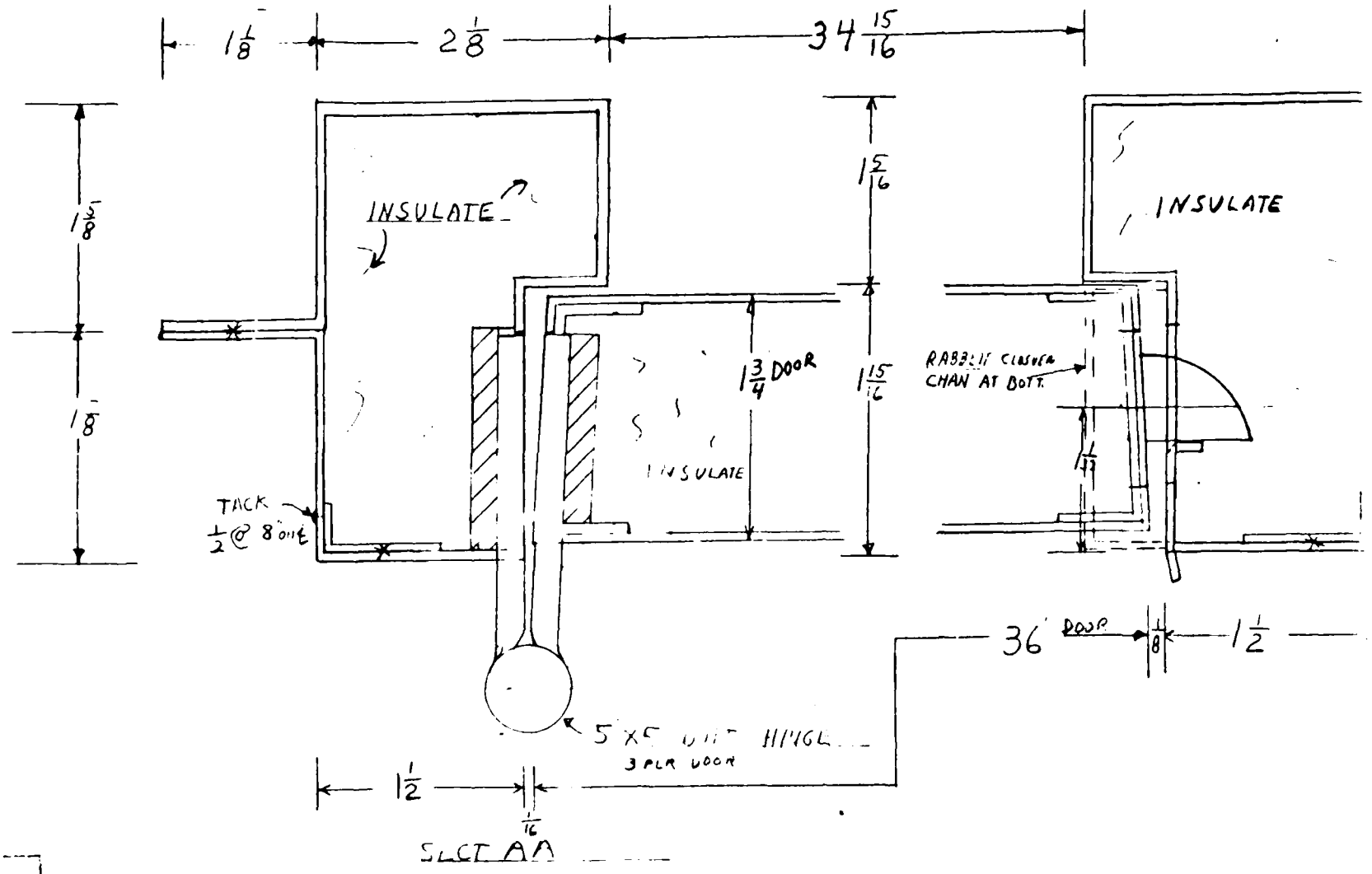
L.G 9-3-98



USNC 142

18

11-3-86



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USNC 142

11-3-86

APPENDIX A

ASTM STANDARD E152-81a
STANDARD METHODS OF FIRE TESTS OF DOOR ASSEMBLIES

A P P E N D I X A

GENERAL:

This appendix contains the correlated temperature, heat flux and pressure data obtained during the fire tests conducted on October 7 and 8, 1986.

THERMOCOUPLE LOCATIONS:

The thermocouple locations on the unexposed face of each assembly are shown on ILL. 17, and correspond to the shown channel numbers on the following data charts.

The location of the special furnace thermocouple grid is shown on ILL. 15

OTHER INSTRUMENTATION:

The location of the pressure taps, radiometers, and calorimeters is shown on ILL. 17.

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 1	1N 1	2S 1	2N 1
0:10	0.0	69.5	75.8	76.5
5:10	0.0	84.8	78.8	81.6
10:10	0.0	187.2	138.2	120.5
15:10	0.0	308.0	223.0	179.4
20:10	0.0	411.8	304.7	231.3
25:10	0.0	503.5	406.2	308.5
30:10	0.0	383.1	491.0	348.6
35:10	0.0	445.9	554.2	407.8
40:10	0.0	445.9	574.0	419.2
45:10	0.0	467.6	597.0	435.5
50:10	0.0	590.4	609.4	439.8
55:10	0.0	504.4	610.4	477.9
60:10	0.0	506.0	643.6	473.3

UNEXPOSED SURFACE TEMPERATURE - HOSE PORTS

NOTE: Temperatures were not measured on door 1S for Channels 1, 2, 3 and 4 since it did not contain a hose port.

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 2	1N 2	2S 2	2N 2
0:10	0.0	69.1	76.8	77.7
5:10	0.0	82.4	78.5	85.3
10:10	0.0	237.6	209.8	153.6
15:10	0.0	690.5	370.3	246.3
20:10	0.0	533.0	489.0	334.6
25:10	0.0	466.2	593.2	403.4
30:10	0.0	540.4	660.5	460.4
35:10	0.0	531.6	718.3	499.7
40:10	0.0	665.0	734.6	521.2
45:10	0.0	719.5	723.9	521.2
50:10	0.0	789.1	733.1	533.1
55:10	0.0	771.6	764.2	538.7
60:10	0.0	748.6	708.3	553.6

UNEXPOSED SURFACE TEMPERATURES - HOSE PORTS

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 3	1N 3	2S 3	2N 3
0:10	0.0	69.8	75.9	77.6
5:10	0.0	80.0	84.4	91.4
10:10	0.0	170.4	170.7	152.8
15:10	0.0	331.2	267.4	329.7
20:10	0.0	391.4	354.4	568.1
25:10	0.0	424.4	431.8	650.2
30:10	0.0	457.6	529.2	692.8
35:10	0.0	460.3	570.1	708.6
40:10	0.0	492.7	593.6	725.9
45:10	0.0	509.1	603.5	742.9
50:10	0.0	685.4	610.0	757.3
55:10	0.0	610.4	617.2	764.8
60:10	0.0	633.7	647.6	787.1

UNEXPOSED SURFACE TEMPERATURES - HOSE PORTS

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

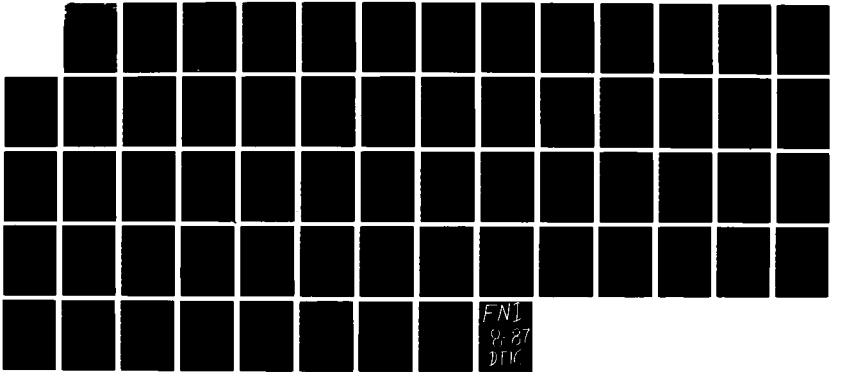
Temperature Degrees F

SAMPLE	1S	1N	2S	2N
CHAN(NOS.)	4	4	4	4
TIME				
0:10	0.0	71.7	74.7	76.5
5:10	0.0	86.0	83.0	81.2
10:10	0.0	139.2	140.3	121.0
15:10	0.0	223.4	228.7	188.6
20:10	0.0	281.0	317.3	250.4
25:10	0.0	321.3	412.0	306.9
30:10	0.0	360.4	473.8	355.1
35:10	0.0	382.3	535.5	390.0
40:10	0.0	416.1	551.9	403.5
45:10	0.0	427.5	573.9	420.
50:10	0.0	496.1	568.5	427.
55:10	0.0	458.8	578.6	443.
60:10	0.0	472.9	588.6	[illegible]

UNEXPOSED SURFACE TEMPERATURES - HOSE PORTS

AD-A182 474 EVALUATING FIRE DOORS WITH HOSE PORTS(U) COAST GUARD 2/2
GROTON CT MARINE FIRE AND SAFETY RESEARCH STAFF
D E BEENE JUN 87 CG-MFSRS-62 USCG-M-1-87

UNCLASSIFIED F/G 13/12 NL



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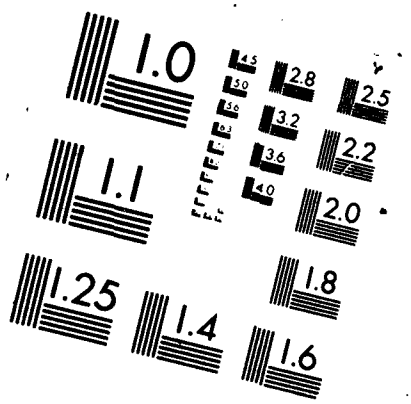
9-87
DTIC



United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 5	1N 5	2S 5	2N 5
0:10	68.0	68.6	74.5	76.3
5:10	74.7	72.3	77.0	79.9
10:10	116.7	116.9	149.1	120.0
15:10	189.0	195.7	179.8	186.6
20:10	245.9	293.1	245.2	251.9
25:10	292.2	401.0	311.5	322.3
30:10	340.4	478.6	356.6	377.9
35:10	371.9	542.3	601.4	403.8
40:10	401.7	558.1	672.4	427.0
45:10	413.1	587.8	704.7	439.7
50:10	435.2	618.6	725.5	446.3
55:10	457.3	628.5	743.6	455.0
60:10	470.6	669.9	761.1	486.2

UNEXPOSED SURFACE TEMPERATURES - FRAME

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 6	1N 6	2S 6	2N 6
0:10	68.7	72.2	81.1	96.2
5:10	119.7	153.1	182.0	163.7
10:10	232.9	318.4	167.2	465.7
15:10	362.5	524.1	224.6	659.3
20:10	536.6	668.6	277.3	833.4
25:10	602.6	743.8	292.4	863.0
30:10	639.4	795.1	311.8	909.6
35:10	666.0	830.1	330.5	931.5
40:10	673.1	851.1	340.2	956.5
45:10	689.1	863.9	350.9	968.5
50:10	731.5	901.7	356.1	1000.6
55:10	732.5	908.7	363.7	1021.4
60:10	756.5	932.6	368.7	1047.6

UNEXPOSED SURFACE TEMPERATURES - FRAME

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 7	1N 7	2S 7	2N 7
0:10	72.8	75.2	76.8	90.0
5:10	178.8	193.4	108.3	369.1
10:10	280.9	293.0	284.6	465.3
15:10	370.5	423.0	377.0	580.3
20:10	438.0	449.5	436.8	675.8
25:10	451.4	466.9	486.2	753.1
30:10	470.6	487.6	522.4	785.7
35:10	499.4	514.9	570.9	817.5
40:10	511.3	513.4	597.6	826.2
45:10	532.0	530.0	615.2	841.8
50:10	545.5	512.9	628.5	862.1
55:10	560.1	495.9	636.9	875.4
60:10	568.6	521.2	644.6	884.5

UNEXPOSED SURFACE TEMPERATURES - FRAME

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 8	1N 8	2S 8	2N 8
0:10	70.7	71.2	75.1	80.7
5:10	286.4	187.9	95.5	198.2
10:10	726.5	428.5	214.4	541.5
15:10	964.8	828.9	378.7	783.7
20:10	1032.3	885.8	464.3	929.4
25:10	1047.0	871.6	532.9	1002.8
30:10	1080.0	891.9	570.8	1019.9
35:10	1084.0	860.1	606.3	1046.2
40:10	1112.6	887.4	619.7	1050.4
45:10	1142.3	889.7	641.3	1037.7
50:10	1157.5	920.1	652.3	1045.8
55:10	1160.7	933.8	664.7	1055.0
60:10	1182.8	971.1	680.5	1071.7

UNEXPOSED SURFACE TEMPERATURE - FRAME

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 9	1N 9	2S 9	2N 9
0:10	74.4	78.2	85.3	81.2
5:10	79.7	88.9	153.6	86.1
10:10	110.3	142.0	217.6	136.4
15:10	201.6	321.4	304.5	247.3
20:10	291.1	419.7	395.2	371.2
25:10	370.6	451.7	451.4	469.8
30:10	429.0	515.1	495.9	575.4
35:10	464.2	537.8	542.1	607.2
40:10	482.6	557.7	577.1	630.0
45:10	497.4	568.6	603.0	643.5
50:10	514.9	577.5	622.6	652.8
55:10	533.6	588.5	638.6	662.9
60:10	552.3	611.0	655.3	672.0

UNEXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 10	1N 10	2S 10	2N 10
0:10	147.3	159.1	120.6	131.2
5:10	626.2	636.0	604.3	641.6
10:10	1022.1	1112.9	1047.3	1142.8
15:10	1117.8	1250.1	1133.5	1251.5
20:10	1169.0	1313.8	1151.9	1303.2
25:10	1200.0	1342.9	1213.5	1360.3
30:10	1249.3	1399.9	1270.1	1399.3
35:10	1253.2	1406.1	1322.3	1450.0
40:10	1270.4	1413.8	1344.1	1475.8
45:10	1298.0	1441.2	1373.5	1498.5
50:10	1336.0	1458.7	1393.9	1521.2
55:10	1355.4	1520.7	1422.9	1545.9
60:10	1398.8	1554.6	1452.8	1581.9

EXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 11	1N 11	2S 11	2N 11
0:10	74.8	75.0	77.3	79.8
5:10	80.3	81.6	80.4	83.8
10:10	117.8	124.1	110.0	129.1
15:10	311.6	265.0	330.7	280.3
20:10	446.2	391.2	433.1	488.8
25:10	561.6	496.8	511.1	616.2
30:10	623.0	551.7	601.1	683.8
35:10	657.5	603.3	665.0	720.9
40:10	680.2	620.4	702.5	761.1
45:10	700.4	632.9	731.4	793.1
50:10	727.3	656.4	753.2	825.8
55:10	750.2	682.2	770.9	863.2
60:10	784.0	723.7	792.0	906.4

UNEXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 12	1N 12	2S 12	2N 12
0:10	142.4	152.6	107.4	126.8
5:10	613.7	733.7	581.2	642.8
10:10	1080.2	1122.0	1095.2	1144.7
15:10	1196.8	1253.0	1178.3	1265.2
20:10	1254.4	1312.0	1217.0	1321.5
25:10	1308.9	1346.0	1271.4	1378.1
30:10	1340.7	1397.5	1318.5	1415.4
35:10	1348.8	1403.0	1371.1	1464.5
40:10	1365.1	1413.7	1388.8	1491.0
45:10	1394.2	1439.3	1417.7	1512.3
50:10	1423.9	1459.6	1436.3	1533.2
55:10	1437.5	1517.1	1463.4	1558.1
60:10	1488.9	1545.3	1498.9	1592.6

EXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 13	1N 13	2S 13	2N 13
0:10	73.7	74.5	76.4	78.5
5:10	76.8	78.6	78.1	80.2
10:10	92.3	104.7	101.1	101.5
15:10	225.2	208.4	198.4	187.9
20:10	333.2	322.2	314.0	294.7
25:10	410.5	418.8	425.7	383.6
30:10	479.4	483.1	546.5	442.8
35:10	517.9	527.1	628.0	475.8
40:10	539.1	545.5	675.4	494.5
45:10	552.1	554.3	704.3	506.6
50:10	565.6	565.3	725.8	513.5
55:10	575.3	573.9	746.8	521.3
60:10	584.7	588.9	773.9	528.5

UNEXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.)	1S 14	1N 14	2S 14	2N 14
TIME				
0:10	140.4	145.7	107.2	128.1
5:10	594.1	664.6	592.5	651.7
10:10	1117.1	1131.7	1103.8	1157.3
15:10	1251.4	1281.4	1194.1	1288.3
20:10	1331.4	1347.2	1265.8	1355.0
25:10	1400.3	1392.8	1320.4	1411.9
30:10	1433.3	1444.4	1371.0	1442.9
35:10	1448.1	1453.9	1426.7	1493.4
40:10	1468.2	1468.7	1439.2	1517.9
45:10	1500.1	1499.9	1461.7	1539.0
50:10	1530.3	1520.2	1484.0	1559.6
55:10	1530.6	1571.3	1510.8	1588.7
60:10	1592.6	1599.0	1546.5	1624.8

EXPOSED SURFACE TEMPERATURES - DOOR

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 15	1N 15	2S 15	2N 15
0:10	0.0	0.0	0.0	72.4
5:10	0.0	0.0	0.0	73.5
10:10	0.0	0.0	0.0	80.4
15:10	0.0	0.0	0.0	97.2
20:10	0.0	0.0	0.0	116.8
25:10	0.0	0.0	0.0	136.1
30:10	0.0	0.0	0.0	155.4
35:10	0.0	0.0	0.0	182.9
40:10	0.0	0.0	0.0	208.3
45:10	0.0	0.0	0.0	229.5
50:10	0.0	0.0	0.0	246.8
55:10	0.0	0.0	0.0	260.7
60:10	0.0	0.0	0.0	271.5

UNEXPOSED SURFACE TEMPERATURES - BULKHEAD PANEL

Note: On the following pages data for several channels per door is not available due to an instrumentation problem.

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 16	1N 16	2S 16	2N 16
0:10	0.0	0.0	0.0	72.1
5:10	0.0	0.0	0.0	72.8
10:10	0.0	0.0	0.0	77.9
15:10	0.0	0.0	0.0	92.2
20:10	0.0	0.0	0.0	112.6
25:10	0.0	0.0	0.0	138.2
30:10	0.0	0.0	0.0	164.6
35:10	0.0	0.0	0.0	196.8
40:10	0.0	0.0	0.0	224.3
45:10	0.0	0.0	0.0	247.5
50:10	0.0	0.0	0.0	265.7
55:10	0.0	0.0	0.0	279.8
60:10	0.0	0.0	0.0	290.2

UNEXPOSED SURFACE TEMPERATURES - BULKHEAD PANEL

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 17	1N 17	2S 17	2N 17
0:10	0.0	0.0	0.0	71.5
5:10	0.0	0.0	0.0	71.9
10:10	0.0	0.0	0.0	75.0
15:10	0.0	0.0	0.0	85.3
20:10	0.0	0.0	0.0	101.1
25:10	0.0	0.0	0.0	121.3
30:10	0.0	0.0	0.0	146.7
35:10	0.0	0.0	0.0	177.3
40:10	0.0	0.0	0.0	208.6
45:10	0.0	0.0	0.0	235.2
50:10	0.0	0.0	0.0	257.4
55:10	0.0	0.0	0.0	274.5
60:10	0.0	0.0	0.0	285.6

UNEXPOSED SURFACE TEMPERATURES - BULKHEAD PANEL

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 18	1N 18	2S 18	2N 18
0:10	0.0	226.8	0.0	199.3
5:10	0.0	919.3	0.0	886.0
10:10	0.0	1249.2	0.0	1227.9
15:10	0.0	1337.8	0.0	1308.7
20:10	0.0	1349.5	0.0	1342.6
25:10	0.0	1381.3	0.0	1353.3
30:10	0.0	1422.9	0.0	1373.0
35:10	0.0	1405.0	0.0	1439.2
40:10	0.0	1415.3	0.0	1459.5
45:10	0.0	1444.8	0.0	1472.8
50:10	0.0	1438.7	0.0	1497.1
55:10	0.0	1524.4	0.0	1516.6
60:10	0.0	1546.7	0.0	1539.7

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 19	1N 19	2S 19	2N 19
0:10	0.0	225.9	0.0	198.8
5:10	0.0	980.6	0.0	942.5
10:10	0.0	1312.2	0.0	1335.1
15:10	0.0	1375.7	0.0	1387.2
20:10	0.0	1400.7	0.0	1400.4
25:10	0.0	1438.9	0.0	1396.3
30:10	0.0	1484.7	0.0	1407.8
35:10	0.0	1452.5	0.0	1497.7
40:10	0.0	1469.9	0.0	1509.9
45:10	0.0	1495.2	0.0	1517.9
50:10	0.0	1494.8	0.0	1538.0
55:10	0.0	1575.7	0.0	1553.9
60:10	0.0	1604.2	0.0	1579.4

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 20	1N 20	2S 20	2N 20
0:10	0.0	214.8	0.0	185.7
5:10	0.0	925.2	0.0	882.0
10:10	0.0	1250.3	0.0	1260.0
15:10	0.0	1306.0	0.0	1312.8
20:10	0.0	1330.1	0.0	1344.0
25:10	0.0	1369.9	0.0	1337.4
30:10	0.0	1425.4	0.0	1353.8
35:10	0.0	1398.1	0.0	1435.1
40:10	0.0	1415.5	0.0	1452.5
45:10	0.0	1441.3	0.0	1464.8
50:10	0.0	1448.0	0.0	1488.2
55:10	0.0	1523.9	0.0	1506.1
60:10	0.0	1556.4	0.0	1531.7

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 21	1N 21	2S 21	2N 21
0:10	0.0	219.5	0.0	168.5
5:10	0.0	902.4	0.0	872.9
10:10	0.0	1327.3	0.0	1259.4
15:10	0.0	1364.1	0.0	1314.1
20:10	0.0	1413.6	0.0	1387.7
25:10	0.0	1463.2	0.0	1417.5
30:10	0.0	1514.5	0.0	1408.1
35:10	0.0	1491.3	0.0	1514.1
40:10	0.0	1507.0	0.0	1529.4
45:10	0.0	1530.2	0.0	1546.3
50:10	0.0	1553.3	0.0	1544.9
55:10	0.0	1595.0	0.0	1554.8
60:10	0.0	1628.8	0.0	1593.0

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 22	1N 22	2S 22	2N 22
0:10	0.0	220.6	0.0	174.3
5:10	0.0	1063.1	0.0	1006.1
10:10	0.0	1441.3	0.0	1402.6
15:10	0.0	1448.5	0.0	1416.8
20:10	0.0	1498.8	0.0	1471.3
25:10	0.0	1543.6	0.0	1467.8
30:10	0.0	1599.4	0.0	1449.7
35:10	0.0	1555.6	0.0	1568.2
40:10	0.0	1578.2	0.0	1578.6
45:10	0.0	1597.1	0.0	1587.4
50:10	0.0	1616.6	0.0	1580.4
55:10	0.0	1652.0	0.0	1583.2
60:10	0.0	1695.3	0.0	1617.0

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 23	1N 23	2S 23	2N 23
0:10	0.0	191.6	0.0	140.0
5:10	0.0	1130.6	0.0	1011.6
10:10	0.0	1413.9	0.0	1384.2
15:10	0.0	1408.9	0.0	1402.3
20:10	0.0	1467.8	0.0	1437.3
25:10	0.0	1510.7	0.0	1418.7
30:10	0.0	1577.2	0.0	1419.3
35:10	0.0	1531.6	0.0	1525.0
40:10	0.0	1563.4	0.0	1534.7
45:10	0.0	1584.9	0.0	1549.8
50:10	0.0	1599.7	0.0	1549.0
55:10	0.0	1632.5	0.0	1560.8
60:10	0.0	1680.4	0.0	1591.6

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE	1S	1N	2S	2N
CHAN(NOS.)	24	24	24	24
TIME				
0:10	0.0	212.1	0.0	175.1
5:10	0.0	829.3	0.0	820.4
10:10	0.0	1302.0	0.0	1240.7
15:10	0.0	1376.5	0.0	1315.6
20:10	0.0	1450.6	0.0	1437.1
25:10	0.0	1503.3	0.0	1497.3
30:10	0.0	1551.7	0.0	1478.0
35:10	0.0	1538.7	0.0	1555.3
40:10	0.0	1557.3	0.0	1573.3
45:10	0.0	1586.6	0.0	1584.4
50:10	0.0	1611.5	0.0	1587.9
55:10	0.0	1634.0	0.0	1597.1
60:10	0.0	1673.8	0.0	1615.5

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE CHAN(NOS.) TIME	1S 35	1N 45	2S 25	2N 55
0:10	0.0	211.6	0.0	187.0
5:10	0.0	1005.0	0.0	1005.0
10:10	0.0	1437.2	0.0	1370.5
15:10	0.0	1481.6	0.0	1430.3
20:10	0.0	1552.2	0.0	1530.4
25:10	0.0	1601.0	0.0	1558.2
30:10	0.0	1643.6	0.0	1521.6
35:10	0.0	1621.3	0.0	1603.9
40:10	0.0	1644.0	0.0	1624.6
45:10	0.0	1666.6	0.0	1632.2
50:10	0.0	1685.1	0.0	1622.6
55:10	0.0	1707.0	0.0	1632.6
60:10	0.0	1746.2	0.0	1648.0

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Temperature Degrees F

SAMPLE	1S	1N	2S	2N
CHAN(NOS.)	26	26	26	26
TIME				
0:10	0.0	172.3	0.0	134.2
5:10	0.0	1154.1	0.0	863.2
10:10	0.0	1422.1	0.0	1363.5
15:10	0.0	1458.7	0.0	1427.6
20:10	0.0	1529.3	0.0	1500.0
25:10	0.0	1561.6	0.0	1489.1
30:10	0.0	1624.3	0.0	1486.4
35:10	0.0	1597.7	0.0	1563.3
40:10	0.0	1635.9	0.0	1593.5
45:10	0.0	1656.0	0.0	1602.0
50:10	0.0	1675.4	0.0	1594.4
55:10	0.0	1702.5	0.0	1606.3
60:10	0.0	1744.2	0.0	1638.3

FURNACE TEMPERATURES

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Millimeters of Mercury

SAMPLE CHAN(NOS.) TIME	1S P2*	1N P2*	2S P2*	2N P2*
0:10	0.0000	0.0512	0.0000	0.0236
5:10	0.0000	0.0762	0.0000	0.0692
10:10	0.0000	0.0937	0.0000	0.0915
15:10	0.0000	0.1188	0.0000	0.1014
20:10	0.0000	0.0988	0.0000	0.1023
25:10	0.0000	0.0763	0.0000	0.1131
30:10	0.0000	0.0882	0.0000	0.1038
35:10	0.0000	0.0908	0.0000	0.0866
40:10	0.0000	0.0901	0.0000	0.0895
45:10	0.0000	0.0893	0.0020	0.0967
50:10	0.0000	0.0886	0.0000	0.0945
55:10	0.0000	0.0865	0.0000	0.0965
60:10	0.0000	0.0936	0.0000	0.1015

FURNACE PRESSURE

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

Millimeters of Mercury

SAMPLE CHAN(NOS.) TIME	1S P1*	1N P1*	2S P1*	2N P1*
0:10	0.0000	-0.0046	0.0000	-0.0046
5:10	0.0000	-0.0317	0.0000	-0.0277
10:10	0.0000	-0.0059	0.0000	-0.0132
15:10	0.0000	0.0019	0.0000	-0.0152
20:10	0.0000	-0.0110	0.0000	0.0119
25:10	0.0000	-0.0305	0.0000	0.0222
30:10	0.0000	-0.0140	0.0000	0.0063
35:10	0.0000	-0.0028	0.0000	-0.0060
40:10	0.0000	-0.0009	0.0000	-0.0054
45:10	0.0000	0.0020	0.0020	0.0036
50:10	0.0000	-0.0084	0.0000	-0.0017
55:10	0.0000	-0.0013	0.0000	-0.0023
60:10	0.0000	0.0046	0.0000	0.0137

FURNACE PRESSURE

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

BTU/sq ft

SAMPLE CHAN(NOS.) TIME	1S R1	1N R1	2S R1	2N R1
0:10	0.0000	0.1254	0.0000	-0.1484
5:10	0.0000	0.9131	0.0000	2.3235
10:10	0.0000	2.0401	0.0000	4.3057
15:10	0.0000	2.3700	0.0000	4.7976
20:10	0.0000	3.1852	0.0000	5.8894
25:10	0.0000	3.7272	0.0000	6.4830
30:10	0.0000	4.2993	0.0000	6.2137
35:10	0.0000	4.3380	0.0000	6.9048
40:10	0.0000	4.3491	0.0000	7.2313
45:10	0.0000	4.6352	0.0000	7.7083
50:10	0.0000	4.8886	0.0000	7.4539
55:10	0.0000	5.0449	0.0000	7.6892
60:10	0.0000	5.3885	0.0000	8.1599

FLUX MEASUREMENTS

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

BTU/sq ft

SAMPLE CHAN(NOS.) TIME	1S R2	1N R2	2S R2	2N R2
0:10	0.0000	0.0272	0.0000	0.0077
5:10	0.0000	0.3950	0.0000	0.1529
10:10	0.0000	2.9782	0.0000	0.7791
15:10	0.0000	3.8895	0.0000	1.2868
20:10	0.0000	4.8822	0.0000	1.6098
25:10	0.0000	5.4319	0.0000	1.7833
30:10	0.0000	6.7340	0.0000	1.6914
35:10	0.0000	6.5166	0.0000	2.1449
40:10	0.0000	6.6671	0.0000	2.1327
45:10	0.0000	6.6525	0.0000	2.0582
50:10	0.0000	7.1269	0.0000	1.9259
55:10	0.0000	7.4947	0.0000	1.9207
60:10	0.0000	7.8459	0.0000	2.0033

FLUX MEASUREMENTS

United States Coast Guard
Bulkhead Door Tests
86NK24389/USNC142
10-7-86 and 10-8-86

BTU/sq ft

SAMPLE CHAN(NOS.) TIME	1S R3	1N R3	2S R3	2N R3
0:10	0.0000	0.1548	0.0000	0.6563
5:10	0.0000	1.8338	0.0000	2.2802
10:10	0.0000	3.6019	0.0000	3.9187
15:10	0.0000	4.0513	0.0000	4.8216
20:10	0.0000	4.6958	0.0000	5.3295
25:10	0.0000	4.9354	0.0000	5.2229
30:10	0.0000	5.7367	0.0000	6.2993
35:10	0.0000	5.5332	0.0000	7.5762
40:10	0.0000	5.8215	0.0000	7.0245
45:10	0.0000	6.2222	0.0000	7.5156
50:10	0.0000	6.4596	0.0000	7.7476
55:10	0.0000	6.7776	0.0000	8.5376
60:10	0.0000	7.1168	0.0000	8.7090

FLUX MEASUREMENTS

APPENDIX B

UNDERWRITERS LABORATORIES, INC., REPORT ON TESTING FIRE DOORS WITH HOSE PORTS

A P P E N D I X B

GENERAL:

This appendix contains the correlated door assemblies deflection and movement data obtained during the fire tests conducted on October 7 and 8, 1986.

DEFLECTION AND MOVEMENT MEASUREMENT LOCATIONS:

The deflection and movement reading locations on the assembly are shown on ILL 17.

Page 2 of this appendix gives the initial positions of the doors. The remaining pages show their positions at different times throughout the tests.

Measurement Location (ILL. 17)	Measurement At 0 min. (in.) Door 1S	Door 1N	Door 2S	Door 2N
M1	1/8	1/8	1/8	1/8
M2	1/8	1/8	1/8	1/8
M3	1/8	1/8	3/16	1/8
M4	1/8	1/8	3/16	1/8
M5	1/8	1/8	1/8	3/16
M6	1/8	1/8	1/16	1/8
M7	1/8	1/8	1/16	1/8
D1	8-1/8	7-9/16	7-9/16	7-7/8
D2	7-1/4	7-7/16	6	7-7/8
D3	8	7-1/2	7-13/16	8

Measurement Location (ILL. 17)	Measurement At 20 min. (in.) Door 1S	Door 1N	Door 2S	Door 2N
M1	0	0	1/16	1/16
M2	♀	♀	1/16	1/16
M3	+-	+-	1/16	1/2
M4	+1-1/8	+1	1/16	1
M5	1/4	1/2	1/16	5/16
M6	1/2	3/8	1/16	5/16
M7	1/2	5/16	1/16	7/16
D1	8-3/16	8-9/16	7-3/4	8-1/8
D2	8-1/2	8	6-1/2	8-5/16
D3	8-1/16	7-7/8	7-7/8	8-1/16

Note: + - Measurement is between M3 and M4, near latch.

Measurement Location (ILL. 17)	Measurement At 40 min. (in.) Door 1S	Door 1N	Door 2S	Door 2N
M1	0	0	0	0
M2	0	0	0	0
M3	+-	+-	1/16	5/8
M4	+1-5/16	+1-1/4	1/8	1-1/4
M5	1/4	7/16	0	5/16
M6	1/2	1/2	3/16	5/16
M7	1/2	1/2	1/16	7/16
D1	8-1/8	8	8-1/8	8-1/4
D2	8-7/8	8-1/4	6-3/9	8-5/8
D3	8-1/8	8	7-7/8	8-1/8

Note: + - Measurement is between M3 and M4, near latch.

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Measurement Location (ILL. 17)	Measurement At 55 min. (in.) Door 1S	Door 1N	Door 2S	Door 2N
M1	0	0	0	0
M2	0	0	0	0
M3	+-	+-	1/16	11/16
M4	+1-5/16	+1-1/4	1/8	1-1/4
M5	1/4	1/16	0	5/16
M6	1/2	1/2	1/4	5/16
M7	1/2	1/2	1/16	7/16
D1	8-1/8	8	6-5/8	8-1/4
D2	8-7/8	8-1/4	7-7/8	8-5/8
D3	8-1/8	8	8-1/4	8-1/8
-			++ 1-5/16	++ 1/2

Notes: + - Measurement is between M3 and M4, near latch.
++ - At bottom latch corner (bottom corner of hose port)

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Measurement Location (ILL. 17)	Measurement After Hose Stream			
	Door 1S	Door 1N	Door 2S	Door 2N
M1	3/16	3/16	1/8	1/16
M2	0	0	3/16	0
M3	1-1/8	1	1/4	1-1/4
M4	1-1/4	1/2	1/4	1-3/16
M5	5/16	1/4	1/4	3/4
M6	1/8	1/4	1/8	1/4
M7	1/8	1/4	1/8	3/8
D1	7-3/4	7-3/4	7-3/4	7-3/4
D2	6-1/2	6-1/4	6	7-1/2
D3	7-1/2	7-5/16	7-3/4 ++ 1-13/16	8 ++ 1-1/2
-	-	-		

Note: ++ - At bottom latch corner (bottom corner of hose port)

A P P E N D I X C

GENERAL:

This appendix contains the temperature, heat flux and pressure data obtained during the fire test conducted on October 7, 1986.

THERMOCOUPLE LOCATIONS:

The thermocouple locations on the unexposed face of the assembly are shown on ILL. 2, and correspond to the channel numbers shown on the following data charts. The thermocouple locations on the exposed face relative to those on the unexposed face were: 1 opposite 6, 2 opposite 7, 3 opposite 8, 11 opposite 20, 12 opposite 21, and 13 opposite 22.

The location of the special furnace thermocouple grid is shown on ILL. 15.

OTHER INSTRUMENTATION:

The location of the pressure taps, radiometers, and calorimeter are shown on ILL. 10. The pressure readings, Channels 34 and 35, are reported in 0.1 mm of mercury. The radiometer/calorimeter readings, Channels 37, 39, 40 were converted from millivolts using the constants shown on ILL. 1[illegible].

GAS CONSUMPTION:

During the test 6000 ft^3 of gas at 1015 BTU/ft^3 were consumed.

AIR FLOW:

Periodically, during the test the amount of air flowing into the furnace was measured. The measurements only take into account the air inlet opening built into the furnace and not openings around the door assemblies or other possible leakage areas in the test assemblies. The flows are the average velocity and do not account for flow variations across the various shapes. The following measurements were taken:

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Time (min)	Velocity (ft/min) (Opening: 16 in.²)	Velocity (ft/min) (Opening: 8 irregular shapes, each approximately 13.8 in.²)
5	15	17
15	24	28
30	25	29
45	15	17
55	20	23

DATA POINT CORRELATIONS:

THE DATA SHOWN ON THE FOLLOWING PAGES IS FOR THE FOLLOWING LOCATIONS:

LOCATION (ILLS 15 AND 17)	CHAN (NOS.) FOR SOUTH DOOR	CHAN (NOS.) FOR NORTH DOOR	CHAN (NOS.) FOR FURNACE
T1 - UNEXPOSED. HOSE PORT. BOTTOM	--	17	--
T2 - UNEXPOSED. HOSE PORT. JAMB	--	15	--
T3 - UNEXPOSED. HOSE PORT. TOP	--	16	--
T4 - UNEXPOSED. HOSE PORT. HINGE	--	18	--
T5 - UNEXPOSED. DOOR FRAME. BOTTOM	9	23	--
T6 - UNEXPOSED. DOOR FRAME. LATCH	4	14	--
T7 - UNEXPOSED. DOOR FRAME. TOP	5	19	--
T8 - UNEXPOSED. DOOR FRAME. HINGE	10	24	--
T9 - UNEXPOSED. DOOR. TOP	6	20 *	--
T10 - EXPOSED. DOOR. TOP	1	11	--
T11 - UNEXPOSED. DOOR. MIDDLE	7	21 *	--
T12 - EXPOSED. DOOR. MIDDLE	2	12	--
T13 - UNEXPOSED. DOOR. BOTTOM	8	22 *	--
T14 - EXPOSED. DOOR. BOTTOM	3	13	--
T15 - UNEXPOSED. BULKHEAD. TOP	--	--	--
T16 - UNEXPOSED. BULKHEAD. MIDDLE	--	--	--
T17 - UNEXPOSED. BULKHEAD. BOTTOM	--	--	--
P1 - PRESSURE. TOP OF HOSE PORT	--	--	35
P2 - PRESSURE. TOP OF DOOR	--	--	34
R1 - FLUX. BOTTOM OF DOOR	--	--	40
R2 - FLUX. MIDDLE OF DOOR	--	--	39
R3 - FLUX. TOP OF DOOR	--	--	37
T53 - SPECIAL FURNACE GRID. TOP FRONT	--	--	25
T54 - SPECIAL FURNACE GRID. TOP MIDDLE	--	--	26
T55 - SPECIAL FURNACE GRID. TOP BACK	--	--	27
T56 - SPECIAL FURNACE GRID. MIDDLE FRONT	--	--	28
T57 - SPECIAL FURNACE GRID. MIDDLE MIDDLE	--	--	29
T58 - SPECIAL FURNACE GRID. MIDDLE BACK	--	--	30
T59 - SPECIAL FURNACE GRID. BOTTOM FRONT	--	--	31
T60 - SPECIAL FURNACE GRID. BOTTOM MIDDLE	--	--	32
T61 - SPECIAL FURNACE GRID. BOTTOM BACK	--	--	33

HJG:DP

United States Coast Guard
Bulkhead Door Test
86NK24389/USNC142
10-7-86

Temperature Degrees F

CHAN(NOS.) TIME	1	2	3	4
0:10	147.3	142.4	140.4	70.7
5:10	626.2	613.7	594.1	286.4
10:10	1022.1	1080.2	1117.1	726.5
15:10	1117.8	1196.8	1251.4	964.8
20:10	1169.0	1254.4	1331.4	1032.3
25:10	1200.0	1308.9	1400.3	1047.0
30:10	1249.3	1340.7	1433.3	1080.0
35:10	1253.2	1348.8	1448.1	1084.0
40:10	1270.4	1365.1	1468.2	1113.6
45:10	1298.0	1394.2	1500.1	1142.3
50:10	1336.0	1423.9	1530.3	1157.5
55:10	1355.4	1437.5	1530.6	1160.7
60:10	1398.8	1488.9	1592.6	1182.8

United States Coast Guard
Bulkhead Door Test
86NK24389/USNC142
10-7-86

Temperature Degrees F

CHAN(NOS.) TIME	5	6	7	8
0:10	72.8	74.4	74.8	75.7
5:10	178.8	79.7	80.3	76.8
10:10	280.9	110.3	117.8	92.3
15:10	370.5	201.6	311.6	225.8
20:10	438.0	291.1	446.2	331.2
25:10	451.4	370.6	561.6	410.5
30:10	470.6	429.0	623.0	479.2
35:10	499.4	464.2	657.5	517.1
40:10	511.3	482.6	680.2	539.1
45:10	532.0	497.4	700.4	552.1
50:10	545.5	514.9	727.3	560.6
55:10	560.1	533.6	750.2	572.1
60:10	568.6	552.3	784.0	584.7

United States Coast Guard
Bulkhead Door Test
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10-7-86

Temperature Degrees F

CHAN(NOS.) TIME	9	10	11	12
0:10	68.0	68.7	159.1	152.6
5:10	74.7	119.7	636.0★	733.7
10:10	116.7	232.9	1112.9	1122.0
15:10	189.0	362.5	1250.1	1253.0
20:10	245.9	536.6	1313.8	1312.3
25:10	292.2	602.6	1342.9	1346.0
30:10	340.4	639.4	1399.9	1397.5
35:10	371.9	666.0	1406.1	1403.0
40:10	401.7	673.1	1413.8	1413.7
45:10	413.1	689.1	1441.2	1439.3
50:10	435.2	731.5	1458.7	1459.6
55:10	457.3	732.5	1528.7	1517.1
60:10	470.6	756.5	1554.6	1545.3

★ - Thermocouple malfunction, approximate temperature

United States Coast Guard
Bulkhead Door Test
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10-7-86

Temperature Degrees F

CHAN(NOS.) TIME	13	14	15	16
0:10	145.7	71.2	69.1	69.8
5:10	664.6	187.9	82.4	80.0
10:10	1131.7	428.5	237.6	170.4
15:10	1281.4	828.9	690.5	331.2
20:10	1347.2	885.8	533.0	391.4
25:10	1392.8	871.6	466.2	424.4
30:10	1444.4	891.9	540.4	457.6
35:10	1453.9	860.1	531.6	469.3
40:10	1468.7	887.4	665.0	492.7
45:10	1499.9	889.7	719.5	509.1
50:10	1520.2	920.1	709.1	685.4
55:10	1571.3	933.8	771.6	610.4
60:10	1599.0	971.1	748.6	633.7

United States Coast Guard
Bulkhead Door Test
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Temperature Degrees F

CHAN(NOS.) TIME	17	18	19	20
0:10	69.5	71.7	75.2	78.2
5:10	84.8	86.0	193.4	88.9
10:10	187.2	139.2	293.0	142.0
15:10	308.0	223.4	423.0	321.4
20:10	411.8	281.0	449.5	419.7
25:10	503.5	321.3	466.9	451.7
30:10	383.1	360.4	487.6	515.1
35:10	445.9	382.3	514.9	537.0
40:10	445.9	416.1	513.4	557.7
45:10	467.6	427.5	530.0	568.6
50:10	590.4	496.1	512.9	577.5
55:10	504.4	458.8	495.9	580.5
60:10	506.0	472.9	521.2	611.0

United States Coast Guard
Bulkhead Door Test
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Temperature Degrees F

CHAN(NOS.) TIME	21	22	23	24
0:10	75.0	74.5	68.6	72.2
5:10	81.6	78.6	72.3	153.1
10:10	124.1	104.7	116.9	318.4
15:10	265.0	208.4	195.7	524.1
20:10	391.2	322.2	293.1	666.0
25:10	496.8	418.8	401.0	743.8
30:10	551.7	483.1	478.6	795.1
35:10	603.3	527.1	542.3	830.1
40:10	620.4	545.5	558.1	851.1
45:10	632.9	554.3	587.8	863.9
50:10	656.4	565.3	618.6	901.7
55:10	682.2	573.9	628.5	908.7
60:10	723.7	588.9	669.9	932.6

United States Coast Guard
Bulkhead Door Test
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Temperature Degrees F

CHAN(NOS.) TIME	25	26	27	28
0:10	226.8	225.9	214.8	219.5
5:10	919.3	980.6	925.2	902.4
10:10	1249.2	1312.2	1250.3	1327.3
15:10	1337.8	1375.7	1306.0	1364.1
20:10	1349.5	1400.7	1330.1	1413.6
25:10	1381.3	1438.9	1369.9	1463.2
30:10	1422.9	1484.7	1425.4	1514.5
35:10	1405.0	1452.5	1398.1	1491.3
40:10	1415.3	1469.9	1415.5	1507.0
45:10	1444.8	1495.2	1441.3	1530.3
50:10	1438.7	1494.8	1448.0	1553.3
55:10	1524.4	1575.7	1523.9	1595.0
60:10	1546.7	1604.2	1556.4	1628.8

United States Coast Guard
Bulkhead Door Test
86NK24389/USNC142
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Temperature Degrees C

CHAN(NOS.) TIME	29	30	31	32	33
0:10	220.6	191.6	212.1	211.6	173.3
5:10	1063.1	1130.6	829.3	1005.0	1154.1
10:10	1441.3	1413.9	1302.0	1437.2	1422.1
15:10	1448.5	1408.9	1376.5	1481.6	1458.7
20:10	1498.8	1467.8	1450.6	1552.2	1529.3
25:10	1543.6	1510.7	1503.2	1601.9	1561.6
30:10	1599.4	1577.2	1551.7	1643.6	1624.3
35:10	1555.6	1531.6	1538.7	1621.3	1597.7
40:10	1578.2	1563.4	1557.3	1644.9	1635.9
45:10	1597.1	1584.9	1586.6	1666.6	1656.6
50:10	1616.6	1599.7	1611.5	1685.1	1675.4
55:10	1652.0	1632.5	1634.0	1707.9	1702.5
60:10	1695.3	1680.4	1673.8	1746.2	1744.2

United States Coast Guard
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Volts

CHAN(NOS.) TIME	34	35
0:10	0.5117	-0.0464
5:10	0.7622	-0.3173
10:10	0.9369	-0.0591
15:10	1.1884	0.0188
20:10	0.9882	-0.1103
25:10	0.7626	-0.3049
30:10	0.8817	-0.1405
35:10	0.9081	-0.0278
40:10	0.9007	-0.0094
45:10	0.8933	0.0200
50:10	0.8855	-0.0839
55:10	0.8646	-0.0132
60:10	0.9359	0.0464

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Millivolts

CHAN(NOS.) TIME	37	39	40
0:10	0.0730	0.0130	0.1460
5:10	0.8650	0.1890	1.0630
10:10	1.6990	1.4250	2.3750
15:10	1.9110	1.8610	3.7590
20:10	2.2150	2.3360	3.7080
25:10	2.3280	2.5990	4.3090
30:10	2.7060	3.2220	5.0050
35:10	2.6100	3.1180	5.0500
40:10	2.7460	3.1900	5.0630
45:10	2.9350	3.1830	5.3960
50:10	3.0470	3.4100	5.6910
55:10	3.1970	3.5860	5.8700
60:10	3.3570	3.7540	6.2730

A P P E N D I X D

GENERAL:

This appendix contains the temperature, heat flux and pressure data obtained during the fire test conducted on October 8, 1986.

THERMOCOUPLE LOCATIONS:

The thermocouple locations on the unexposed face of the assembly are shown on ILL. 9, and correspond to the shown channel numbers minus 24, on the following data charts. The thermocouples on the exposed face were: 25 opposite 30, 26 opposite 31, 27 opposite 32, 39 opposite 44, 40 opposite 45, and 41 opposite 46.

The location of the special furnace thermocouple grid is shown on ILL. 15.

OTHER INSTRUMENTATION:

The location of the pressure taps, radiometers, and calorimeter is shown on ILL. 10. The pressure readings, Channels 44 and 45, are reported in 0.1 mm of mercury. The radiometer/calorimeter readings, Channels 47, 49, 50 were converted from millivolts using the constant shown on ILL. 17.

GAS CONSUMPTION:

During the test 6500 ft^3 of gas at 1015 BTU/ft^3 were consumed.

AIR FLOW:

Periodically, during the test the amount of air flowing into the furnace was measured. The measurements only takes into account the air opening built into the furnace and not openings around the door assemblies or possible leakage. The flows are the average velocity and do not account for flow variations across the various shapes.

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Time (min)	Velocity (ft.min) (Opening: 16 in.^{2})	Velocity (ft/min) (Opening: 8 irregular shapes, each approximately 13.8 in.^{2})
5	14	16
15	22	26
30	26	30
45	20	23
55	18	21

DATA POINT CORRELATION:

THE DATA SHOWN ON THE FOLLOWING PAGES IS FOR THE FOLLOWING LOCATIONS:

LOCATION (ILLS 15 AND 17)	CHAN (NOS.) FOR SOUTH DOOR	CHAN (NOS.) FOR NORTH DOOR	CHAN (NOS. FOR FURNACE
T1 - UNEXPOSED. HOSE PORT. BOTTOM	12	26	--
T2 - UNEXPOSED. HOSE PORT. JAMB	14	28	--
T3 - UNEXPOSED. HOSE PORT. TOP	11	25	--
T4 - UNEXPOSED. HOSE PORT. HINGE	10	24	--
T5 - UNEXPOSED. DOOR FRAME. BOTTOM	9	23	--
T6 - UNEXPOSED. DOOR FRAME. LATCH	13	27	--
T7 - UNEXPOSED. DOOR FRAME. TOP	5	19	--
T8 - UNEXPOSED. DOOR FRAME. HINGE	4	18	--
T9 - UNEXPOSED. DOOR. TOP	6	20	--
T10 - EXPOSED. DOOR. TOP	1	15	--
T11 - UNEXPOSED. DOOR. MIDDLE	7	21	--
T12 - EXPOSED. DOOR. MIDDLE	2	16	--
T13 - UNEXPOSED. DOOR. BOTTOM	8	22	--
T14 - EXPOSED. DOOR. BOTTOM	3	17	--
T15 - UNEXPOSED. BULKHEAD. TOP	38	--	--
T16 - UNEXPOSED. BULKHEAD. MIDDLE	39	--	--
T17 - UNEXPOSED. BULKHEAD. BOTTOM	40	--	--
P1 - PRESSURE. TOP OF HOSE PORT	--	--	45
P2 - PRESSURE. TOP OF DOOR	--	--	44
R1 - FLUX. BOTTOM OF DOOR	--	--	50
R2 - FLUX. MIDDLE OF DOOR	--	--	49
R3 - FLUX. TOP OF DOOR	--	--	47
T53 - SPECIAL FURNACE GRID. TOP FRONT	--	--	29
T54 - SPECIAL FURNACE GRID. TOP MIDDLE	--	--	30
T55 - SPECIAL FURNACE GRID. TOP BACK	--	--	31
T56 - SPECIAL FURNACE GRID. MIDDLE FRONT	--	--	32
T57 - SPECIAL FURNACE GRID. MIDDLE MIDDLE	--	--	33
T58 - SPECIAL FURNACE GRID. MIDDLE BACK	--	--	34
T59 - SPECIAL FURNACE GRID. BOTTOM FRONT	--	--	35
T60 - SPECIAL FURNACE GRID. BOTTOM MIDDLE	--	--	36
T61 - SPECIAL FURNACE GRID. BOTTOM BACK	--	--	37

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Temperature Degrees F

CHAN(NOS.) TIME	1	2	3	4
0:12	120.6	107.4	107.3	77.1
5:12	604.3	581.2	592.5	97.1
10:12	1047.3	1095.2	1103.8	214.4
15:12	1133.5	1178.3	1194.1	371.1
20:12	1151.9	1217.0	1265.8	464.1
25:11	1213.5	1271.4	1320.4	532.1
30:11	1270.1	1318.5	1371.9	57
35:11	1322.3	1371.1	1426.7	606.1
40:11	1344.1	1388.8	1439.2	615.1
45:11	1373.5	1417.7	1461.7	641.1
50:11	1393.9	1436.3	1484.0	652.1
55:11	1422.9	1463.4	1510.8	664.1
60:11	1452.3	1498.9	1546.3	681.1

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Temperature Degrees F

CHAN(NOS.) TIME	5	6	7	8
0:12	76.8	85.3	77.3	76.4
5:12	108.3	153.6	80.4	78.1
10:12	284.6	217.6	110.0	101.1
15:12	377.0	304.5	330.7	198.4
20:12	436.8	395.2	433.1	314.0
25:11	486.2	451.4	511.1	425.7
30:11	522.4	495.9	601.1	546.3
35:11	570.9	542.1	665.9	628.0
40:11	597.6	577.1	702.5	675.4
45:11	615.2	603.0	731.4	704.3
50:11	628.5	622.6	753.2	725.3
55:11	636.9	638.6	770.9	746.3
60:11	644.6	655.3	792.0	773.1

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Temperature Degrees C

CHAN(NOS.) TIME	9	10	11	12
0:12	74.5	74.7	75.9	78.2
5:12	77.0	83.0	84.4	78.8
10:12	149.1	140.3	170.7	136.2
15:12	179.8	228.7	267.4	223.9
20:12	245.2	317.3	354.4	304.1
25:11	311.5	412.0	431.8	406.2
30:11	356.6	473.8	529.3	491.9
35:11	601.4	535.5	570.1	554.2
40:11	672.4	551.9	593.6	574.0
45:11	704.7	573.9	603.5	597.2
50:11	725.5	568.5	610.6	609.4
55:11	743.6	578.6	617.2	610.4
60:11	761.1	588.6	647.6	643.1

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Temperature Degrees F

CHAN(NOS.) TIME	13	14	15	16
0:12	81.1	76.8	131.2	126.8
5:12	182.0	78.5	641.6	642.8
10:12	167.2	209.8	1142.3	1144.7
15:12	224.6	370.3	1251.5	1265.2
20:12	277.3	489.0	1303.2	1321.5
25:11	292.4	593.2	1360.2	1378.1
30:11	311.8	660.5	1399.8	1415.4
35:11	330.5	718.3	1450.0	1464.5
40:11	340.2	734.6	1475.8	1491.0
45:11	350.9	783.9	1498.5	1512.2
50:11	356.1	788.1	1521.2	1538.2
55:11	363.7	764.2	1545.9	1558.1
60:11	368.7	788.3	1581.9	1593.6

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Temperature degrees

CHAN(NOS.) TIME	17	18	19	[illegible]
0:12	128.1	80.7	90.0	81.[illegible]
5:12	651.7	198.2	369.1	86.[illegible]
10:12	1157.2	541.5	465.3	135.[illegible]
15:12	1288.3	783.7	580.8	247.[illegible]
20:12	1355.0	929.4	675.8	371.[illegible]
25:11	1411.9	1002.8	753.1	467.[illegible]
30:11	1442.9	1019.9	785.7	575.4
35:11	1493.4	1046.2	817.5	607.[illegible]
40:11	1517.9	1050.4	826.2	630.[illegible]
45:11	1539.0	1037.7	841.3	643.[illegible]
50:11	1559.6	1045.8	862.1	652.[illegible]
55:11	1588.7	1055.0	875.4	663.9
60:11	1624.8	1071.7	884.5	672.[illegible]

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Temperature Degrees F

CHAN(NOS.) TIME	21	22	23	24
0:12	79.8	78.5	76.3	76.5
5:12	83.8	80.2	79.9	81.2
10:12	129.1	101.5	120.0	121.0
15:12	280.8	187.9	186.6	188.6
20:12	488.8	294.7	251.9	250.4
25:11	616.2	383.6	322.3	306.0
30:11	683.8	442.3	377.9	355.1
35:11	720.9	475.8	403.8	390.0
40:11	761.1	494.5	427.0	403.6
45:11	793.4	506.6	439.7	420.3
50:11	825.8	513.5	446.3	427.4
55:11	863.2	521.3	455.0	442.3
60:11	900.4	528.5	486.2	455.0

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Temperature Degrees C

CHAN(NOS.) TIME	25	26	27	28
0:12	77.6	76.5	96.2	77.7
5:12	91.4	81.6	163.7	85.3
10:12	152.8	120.5	465.7	153.6
15:12	229.7	179.4	659.3	246.3
20:12	568.1	231.3	833.4	334.5
25:11	650.2	308.5	863.0	403.4
30:11	693.8	348.6	909.6	460.1
35:11	708.6	407.8	931.5	499.7
40:11	725.9	419.2	956.5	521.2
45:11	742.9	435.5	968.5	521.2
50:11	757.3	439.8	1000.6	533.1
55:11	764.8	477.9	1021.4	533.7
60:11	787.1	473.3	1047.6	553.6

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Temperature Degrees F

CHAN(NOS.) TIME	29	30	31	32
0:12	199.3	198.8	185.7	168.5
5:12	886.0	942.5	882.0	872.9
10:12	1227.9	1335.1	1260.0	1259.4
15:12	1308.7	1387.2	1312.8	1314.1
20:12	1342.6	1400.4	1344.0	1387.7
25:11	1353.3	1396.3	1337.4	1417.3
30:11	1373.0	1407.8	1353.3	1408.1
35:11	1439.2	1497.7	1435.1	1514.1
40:11	1459.5	1509.9	1452.5	1529.4
45:11	1472.8	1517.9	1464.8	1546.3
50:11	1497.1	1538.0	1486.2	1544.1
55:11	1516.6	1553.9	1506.1	1554.3
60:11	1539.7	1579.4	1531.7	1593.0

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Temperature Degrees F

CHAN(NOS.) TIME	33	34	35	36
0:12	174.3	140.0	175.1	187.0
5:12	1006.1	1011.6	829.4	1005.9
10:12	1402.6	1384.2	1240.7	1379.5
15:12	1416.8	1402.3	1315.6	1430.3
20:12	1471.8	1437.3	1437.1	1539.4
25:11	1467.8	1418.7	1497.5	1558.3
30:11	1449.7	1419.3	1478.0	1521.6
35:11	1568.2	1525.0	1555.3	1603.9
40:11	1578.6	1534.7	1573.3	1624.6
45:11	1587.4	1549.8	1584.4	1632.2
50:11	1580.4	1549.0	1587.9	1622.6
55:11	1583.2	1560.8	1597.1	1632.6
60:11	1617.9	1591.6	1618.6	1648.6

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Temperature Degrees F

CHAN(NOS.) TIME	37	38	39	40
0:12	134.2	72.4	72.1	71.5
5:12	863.2	73.5	72.8	71.9
10:12	1363.5	80.4	77.9	75.0
15:12	1427.6	97.2	92.2	85.3
20:12	1500.0	116.8	112.6	101.1
25:11	1489.1	136.1	138.2	121.3
30:11	1486.4	155.4	164.6	146.7
35:11	1563.3	182.9	196.8	177.3
40:11	1593.5	208.3	224.3	208.6
45:11	1602.0	229.5	247.5	235.2
50:11	1594.4	246.8	265.7	257.4
55:11	1606.3	260.7	279.8	274.5
60:11	1638.8	271.5	290.2	285.6

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Volts

CHAN(NOS.) TIME	44	45
0:12	0.2356	-0.0458
5:12	0.6923	-0.2773
10:12	0.9151	-0.1321
15:12	1.0138	-0.1521
20:12	1.0228	0.1187
25:11	1.1307	0.2222
30:11	1.0384	0.0631
35:11	0.8664	-0.0603
40:11	0.8952	-0.0537
45:11	0.9667	0.0362
50:11	0.9449	-0.0174
55:11	0.9645	-0.0233
60:11	1.0147	0.1371

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Millivolts

CHAN(NOS.) TIME	47	49	50
0:12	0.3140	0.0090	-0.0700
5:12	1.0910	0.1780	1.0960
10:12	1.8750	0.9070	2.0310
15:12	2.3070	1.4980	2.2630
20:12	2.5500	1.8740	2.7780
25:11	2.4990	2.0760	3.0580
30:11	3.0140	1.9690	2.9310
35:11	3.6250	2.4970	3.2570
40:11	3.3610	2.5410	3.4110
45:11	3.5960	2.3960	3.6360
50:11	3.7070	2.2420	3.5160
55:11	4.0850	2.2360	3.6270
60:11	4.1670	2.3320	3.8490

END

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DTIC